Master's degree thesis

LOG950 Logistics

The role of air freight services in a firm's supply chain management strategy: a case study of the electromechanical industry in Møre og Romsdal

Ben Stevens

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Preface and acknowledgement

This master thesis is the final and mandatory part of the two-year Master of Science in Logistics program, specialization Supply Chain Management at Molde University College in Norway. As preparation a proposal document has been written and approved in December 2011. The thesis has been written in the period from January until May 2012 under the academic supervision of Professor Dr. Svein Bråthen.

Hereby I would like to express my gratitude to my supervisor Svein Bråthen for his valuable supervision in the form of academic knowledge, constructive feedback, and guidance throughout the writing process of the master thesis.

In addition I sincerely appreciate the contribution of the five firms which participated in the research by providing valuable and in-sight industry information.

Furthermore my deepest gratitude goes to my family for their endless support, strength and believe in me throughout this endeavour. Without their support I would not have been where I am today.

Molde, May 2012.

Ben Stevens.

Abstract

Supply chain networks have become more complex due to trends such as internationalization, increased consumer requirements and shorten product lifecycles. The role of air freight services in a firm's supply chain management strategy in order to manage such complex supply chain networks has been scarcely discussed in scientific literature.

The purpose of this explanatory research is therefore to examine the role of air freight services in a firm's supply chain management strategy by performing a multiple case study including five firms operating in the electromechanical industry in Møre og Romsdal, Norway. Hereby the research puts a large emphasize on describing how a specific set of business attributes and supply chain characteristics influence a firm's demand for air freight services.

The case study reveals that air freight services only play a minor role in the supply chain management strategy of firms operating in the electromechanical industry in Møre og Romsdal. Air freight is mainly used in managing the outbound flow of time-critical spare- and service parts to upstream onshore and offshore customers who operate the focal firm's product. Air freight services are rarely used to accommodate the inbound flow of manufacturing parts and components which can to some extend be explained due to the long planning horizons resulting from the project based engineer-to-order manufacturing environment.

Furthermore the research showed that a firms air freight demand is dependent on a number of business attributes including amongst others the level of internationalization, supply chain structure and type of production system. Finally the research concludes that a firm's air freight demand is highly dependent on the type of industry including its commodities manufactured. Therefore the results of this research cannot be generalized and use to describe the role of air freight services in other industries.

Key words: air freight services - supply chain management - logistics - electromechanical industry - Møre og Romsdal - Norway - multiple case study.

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List of abbreviations

AHTS - Anchor Handling Tug Supply
ANSP - Air Navigation Service Provider
ASA - Air Service Agreement
ATM - Air Traffic Management
ATO - Assemble-to-order
BTO - Buy-to-order
BU - Business Unit
EASA - European Aviation Safety Agency
ECAA - European Common Aviation Area
ETO - Engineer-to-order
E.U. - European Union
HAWB - House Air Waybill
IATA - International Air Transport Association
ICAO - International Civil Aviation Organization
JIT - Just-in-time
KG - Kilogram
LNG - Liquefied Natural Gas
MAWB - Master Air Waybill
MTO - Make-to-order
MTS - Make-to-stock
N.A. - Not Available
OSV - Offshore Supply Vessel
PSO - Public Service Obligation

PSV - Platform Supply Vessel

RTK - Revenue Tonne Kilometer

SAS - Scandinavian Airlines

SCM - Supply Chain Management

STS - Ship-to-stock

TDC - Total Distribution Costs

TKM - Tonne Kilometer

TVRO - TV Receive Only

VSAT - Very Small Aperture Terminal

WWII - World War II

1. Introduction of the research topic

The first chapter of the thesis will shed light on the background of the research topic followed by the formulation of the research questions. Finally it will delineate the research area and provide a definition of air freight services as used in the research.

1.1 Description of the topic

In recent decades modern business management has been subject to a number of significant changes. One of the most profound changes has been the shift of firms that used to compete as solely autonomous entities to firms that compete in supply chain networks (Leinbach and Bowen 2004). Those supply chain networks link focal firms with upstream suppliers and downstream customers with the aim to support a more efficient exchange of information and physical flow of goods. Together with a shift in corporate strategy towards the externalization of non-core activities; i.e. outsourcing, the competitive strength of focal firms have become increasingly dependent on the management of external resources (Leinbach and Bowen 2004; Capineri and Leinbach 2006). This is recognized by Power (2005, p. 252) stating that "as organizations seek to developed partnerships and more effective information links with trading partners, internal processes become interlinked and span the traditional boundaries of firms".

Thereby supply chains are increasingly stretched over longer distances. International upstream suppliers are selected by focal firms to benefit from lower unit costs and economies of scales (Braithwaite 2010). Due to reduced barriers of trade, improved transportation infrastructure, and better information and communication technology firms are able to expand their business practices to broader international downstream markets. This trend of global trade has been strongly increased in recent decades with an average of 5,9% per annum in the period 1950 until 2004 (Hummels 2007).

The increased geographical distance between upstream suppliers, focal firms and downstream consumer markets results in an increasing time pressure on the physical logistics system. Thereby the increasing consumer requirements due to for example the introduction of new production practices such as just-in-time (JIT) and shorten product

lifecycles making demand more volatile and are exaggerating the time pressure on the physical logistical system (Christopher 2000). The importance of the physical movement of goods in international supply chains is recognized by David and Stewart (2010) arguing that time to market in international supply chains is largely influenced by the physical movement of goods which is supported by transportation networks and infrastructure. As concluded by Christopher (2000, p. 37) "the ability to be able to meet the demands of customers for ever-shorter delivery times and to ensure that supply can be synchronized to meet peaks and troughs of demand is clearly of critical importance in this era of 'time-based competition'".

Simultaneously the share of air freight as a mode of transportation in international trade has significantly increased during the last decades compared to other modes of transportation such as road, sea and rail. Even though air freight services accounts only for 1 percent of the total world trade in terms of weight, in terms of value it transports 40 percent of the total world trade (David and Stewart 2010; Zhang and Zhang 2002). One of the most important attributes of air freight services is its speed. Where for example the transportation lead-time of a container vessel is approximately six weeks to transport end products from a Chinese supplier to a European central warehouse, the transportation lead-time of air freight services is only between 3 and 4 days. The '*speed*' provided by air freight services can be a valuable attribute in todays time-based competition by connecting upstream suppliers, focal firms and downstream consumers in networks of complex international supply chains. However at the time of writing little or no scientific research has been done in determining the role of air freight services in a firms supply chain management strategy.

This limitation in scientific research is the starting point of thesis. The main goal of this thesis is to determine the role of air freight services in a firm's supply chain management strategy. The research will thereby put a large emphasize on describing how a specific set of business attributes and supply chain characteristics are influencing a firms demand for air freight services. The relevance of the thesis is explained by the limited available scientific research which combines the emerge of international time-based competition supply chain networks with the increasing role of air freight services in international trade.

The only relevant scientific research which examines the role of air freight services in complex international supply chain networks is the research performed by Leinbach and Bowen (2004) with the working title *'Air cargo services and the electronics industry in Southeast Asia'*. In their work the authors performed a case study of over 120 firms in the electronics industry in Singapore, Penang, Luala Lumpur, and Manila in order to find the drivers behind the usage of air freight services. In the findings it is statistically proven that air freight usage is related to a set of attributes concerning a firm's structure and operation.

This thesis will have common characteristics with the research performed by Leinbach and Bowen but differs substantially on the following points:

- This thesis will focus on a different geographical area namely the county of Møre og Romsdal in Norway;
- The industry examined in this thesis is the electromechanical industry whereas Leinbach and Bowen focus on the electronics industry;
- The research of Leinbach and Bowen provides statistically evidence based on a sample size of more than 120 firms. Due to time and resource limitations this research has an explanatory design and will focus in depth on a sample of 5 case study firms;
- Global production networks[1] are central in the work of Leinbach and Bowen where international supply chains are central in this thesis.

The introduction will continue with the development of the research questions.

1.2 Research questions

Research questions forming the base of any research performed and are covering the research problem which will be explored during the research. Research questions should be formulated in accordance to several criteria in order to be sufficient (Bryman and Bell 2011, p. 82):

[1] Global production networks refers to "the globalized nexus of interconnected functions and operations through which goods and services are produced and distributed" (Leinbach and Bowen 2004, p. 304).

- Research questions have to be formulated in a clear and understandable manner;
- Research questions have to be connected to established theory and research in order to prove the contribution of the research to the field of study;
- Research questions have to be connected to each other to develop a structured thesis;
- Research questions have to be researchable, i.e. enough data should be available to answer the research questions.

The following research questions have been formulated in accordance to the research problem and the abovementioned guidelines, and are introduced with a short paragraph of explanatory information.

The aim of the main research question is to analyse the impact of the availability and quality of airfreight services on the supply chain management strategy of firms. Therefore the main research question has been formulated as:

1. How does the availability and quality of air freight services influence the competitive strength of firms, and does it impact strategically decision making within a firm?

In order to provide a well-structured answer on this research question, several sub research questions have to be developed and researched. Before the impact of the availability of air freight services on the supply chain management strategy can be defined, first the demand for air freight services has to be measured and clarified. This in order to select extensive users and to get an overview of the characteristics of the types of items which are transported by air freight services. Therefore the following sub research question has been developed:

2. What are the characteristics of the demand for air freight services in the electromechanical industry in the Møre og Romsdal?
    a. Which firms are extensive air freight service users in terms of value and weight of the transported items?

b. What are the characteristics of the items which are transported by air freight service, and are there any similarities or differences between these items?

When the demand for air freight services in the industry is specified, it can be analysed if those characteristics are related to the incentives for using air freight services. In relation to this, how are the incentives related to the specific characteristics of air freight services like costs, frequency, quality and speed.

3. How are those air freight services demand characteristics related to the incentives for extensive users to select air freight services instead of road, rail or sea transportation for their items?
   a. How do costs, delivery time, frequency, security and the quality of air freight services influence the transport mode choice for the firms?
   b. Are there besides the abovementioned measures other important incentives for firms to make use of air freight services?

Finally it is if interest to analyse if the use of air freight services is related to the operating characteristics and structure of the firms. This has also been researched by Leinbach and Bowen (2004) regarding the electronics industry in South East Asia.

4. Is the amount of air freight usage related to specific aspects of a firm's structure and operation?
   a. How do production characteristics like process, network and strategy influence the use of air freight services?
   b. What is the impact of customer preferences on the level of usage of air freight services of the firms?
   c. Does the size and level of internationalization of the companies influence the use of air freight?

1.3 Definitions and delineation

In order to keep the research feasible it is important to delineate the research area and to provide clear definitions of the phenomena researched. First a definition of air freight services will be provided followed by the delineation of the research area.

1.3.1 Air freight services

Air freight services are part of a larger industry called air cargo services. Air cargo services can be defined as: “the term air cargo is generally used in the broad sense, to include air freight, mail, and the several types of expediting small package services to which the term air express is now rather loosely applied. In short, almost everything that goes in the cargo compartment on a passenger flight is considered air cargo, except passenger baggage, which is threated as if it were part of the passenger” (O'Connor 2001).

This thesis will focus on air freight services in all its configurations and express services including parcel and door-to-door freight. Express documents and mail will be excluded in this research as it not related with the physical transportation of goods. Thereby following Zhang and Zhang (2002, p. 277) express documents and mail “is expected to decline as paper data can be transmitted with increasing ease via Internet”.

As displayed in figure 1-1, express and mail services will not be covered in this report.

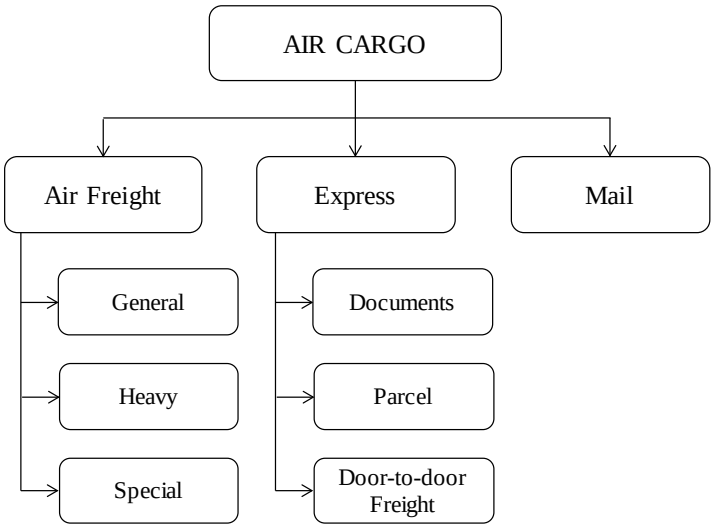

Figure 1-1: Types and subdivisions of air cargo (Halpern 2011).

Since the research includes door-to-door air freight services, also the ground transportation from and to the firms, which is mostly performed by freight forwards, will be considered in this thesis.

1.3.2 Electromechanical industry

The industry which will be examined in the thesis will be the electromechanical industry in Møre og Romsdal. The used definition of the electromechanical industry in this research will be "the development, manufacturing, assembly, installation and maintenance of products and parts which are based on electronic circuits and mechanical systems[2]". The products in the electromechanical industry are consisting of both electronic components and mechanical components which are integrated into the final product. Examples of such products are propulsion systems, vessels and vessel equipment, construction equipment and so on. Frequently these products consist of a large number of components which are likely to have a high value to weight ratio. In addition they can have compact physical dimensions such as in the case of printed circuit boards and are therefore suitable to be distributed by air freight services.

The electromechanical industry has been selected to examine in this research since in the large number of manufactures of marine and oil and gas related products (which are characterised by their electromechanical functions) in the county of Møre og Romsdal.

1.3.3 Møre og Romsdal

Geographically the research will focus on the county of Møre og Romsdal located at the west coast of Norway, with the focus on the municipalities of Ålesund, Kristiansund, and Molde. Møre og Romsdal covers 15.115 km² of surface area and has a population of 256.133 inhabitants, measuring a population density of 17 residents per square kilometre. The number of residents in Møre og Romsdal has increased since 1992 by 7,3 percent. Of the 256.133 residents of Møre og Romsdal, 44.296 are living in Ålesund, 25.456 in Molde and 23.739 in Kristiansund (Statistik Sentralbyrå 2011).

On January 1st, 2012 there were 24.951 enterprises established in Møre og Romsdal. The number of enterprises in Møre og Romsdal has increased since 2002 with 6,3%. Most of

[2] Definition defined by the author.

the enterprises are located in the urban settlements of Ålesund (4.039); Molde (2.345); and Kristiansund (1.940). Compared to 2002 those three municipalities showed all an increase in the number of enterprises. The main industries in Møre og Romsdal are crop and animal production (13,2%); real estate activities (10,5%); retail trade (8,1%); specialized construction activities (6,7%); and construction of buildings (4,9%).

The majority of the enterprises have a small number of employees. When measuring size of the establishments in terms of number of employees; 57,4 percent of all the establishments do not have employees; 21,7 percent employs between 1 and 4 employees; 9,4 percent employs between 5 and 9 employees; 6,0 percent between 10 and 19 employees and 4,1 percent between 20 and 49 employees. Only 0,1 percent of the establishments employ more than 250 employees.

Due to the geographical location of Møre og Romsdal, including various fjords and mountains, surface freight transportation within Møre og Romsdal is highly dependent on an extensive road network including ferries, (toll) tunnels, and bridges which can make transportation of freight costly and time-intensive. The motorway E6 is connecting Møre og Romsdal with the most important (freight) airport of Norway, Gardermoen in Oslo. The road connection covers about 500km and has a duration of approximately seven hours. During winter time sections of the road are sometimes temporary closed due to harsh driving conditions.

Besides road transportation an intermodal railway network is connecting Møre og Romsdal with eleven main cities in Norway, including the capital city of Oslo (Alnabru). The train terminal in Møre og Romsdal is located in the city of Åndalsnes. The service is operated by CargoNet with shuttle trains carrying 20ft and 40ft containers, swap bodies, and semi-trailers. The daily connection departs in Åndalsnes in the morning and arrives at Alnabru in the late evening of the same day (CargoNet 2012).

2. Methodology

In this section an insight is provided in the methodology that is applied in the research, including the research design, data collection, reliability, and validity and the developed conceptual theoretical framework for the research.

2.1 Research design

"A research design provides a framework for the collection and analysis of data" (Bryman and Bell 2011, p. 40). The most appropriate research strategy regarding this thesis is a qualitative research strategy. A qualitative research strategy "can be construed as a research strategy that usually emphasizes words rather than quantification in the collection and analysis of data" (Bryman and Bell 2011, p. 27). Following Bryman and Bell (2011, p. 27) a qualitative research strategy:

- "Predominantly emphasizes an inductive approach to the relationship between theory and research, in which the emphasis is placed on the generations of theories";
- "Has rejected the practices and norms of the natural scientific model and of positivism in particular in preference for an emphasis on the ways in which individuals interpret their social world";
- "Embodies a view of social reality as a constantly shifting emergent property of individuals' creation".

To be more detailed, this qualitative research will be in particularly designed as a qualitative case study. "Qualitative case study methodology provides tools for researchers to study complex phenomena within their context" (Baxter and Jack 2008, p. 544). The role of air freight services in a firm's supply chain management strategy represents the complex phenomena which will be researched in its 'real-world' context. I.e. it can be said that the unit of analysis of this research is air freight services as a process and how it influence strategic decision making of individual firms regarding their supply chain management strategy.

The qualitative case study research design is further more an appropriate research design for this thesis since according to Yin (2003) this research design should be considered when the focus of the research is to answer 'how' and 'why' questions. Since the aim of this thesis is to develop a theoretical framework of 'why' firms are using air freight services and 'how' it is impacting their supply chain strategy, the case study research design is selected as the most appropriate research design for this research.

Within the qualitative case study research design, there are several variations of which the multiple case study will be applied in this research. The multiple case study design "encourage researchers to consider what is unique and what is common across cases, and frequently promotes theoretical reflection on the findings" (Bryman and Bell 2011, p. 63).

The analysing technique used for the multiple case study can be defined as explanatory since as stated earlier the research will focus on answering 'how' and 'why' questions.

Figure 2-1 displays the process of a multiple case study method research design. This process is adapted in constructing and performing the research. First a conceptual theoretical framework will be developed linking the use of air freight services within firms (air freight demand) with both internal and external factors. Hereafter a multiple case study will be applied to collect industry data in order to compare the case study findings with the conceptual theoretical framework. After the analysis, if needed, the conceptual theoretical framework will be adjusted according the case study findings. This report will not display individual case reports but will instead focus on a cross-case report.

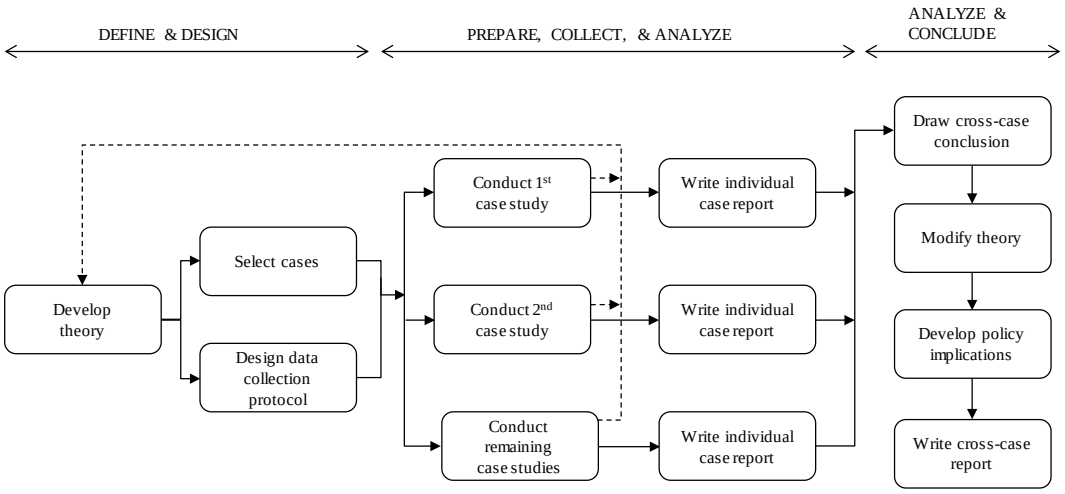

Figure 2-1: Multiple case study method based on (Yin 2003, p. 50).

2.2 Data collection and selection

In general two types of data are recognized in theory namely primary and secondary data. Whereas primary data is collected by the researcher itself, secondary data is already existing and the researcher is not involved in the collection of it (Bryman and Bell 2011). This research will apply both the use of primary and secondary data.

The main source of primary data will be a semi-structured interview. A semi-structured interview typically refers to "a context in which the interviewer has a series of questions that are in the general form of an interview schedule but is able to vary the sequence of questions" (Bryman and Bell 2011, p. 205). To gain the maximum amount of valid data out of the semi-structured interviews, an interview guide is used to structure the interviews. Bryman and Bell (2011, p. 715) refer to an interview guide as a 'structured list of issues to be addressed or questions to be asked in semi-structured interviewing". According to Bryman and Bell (2011, p. 475) an interview guide should be formulated in accordance to several criteria in order to be sufficient:

- A decent amount of questions per topic area should be developed, and the interviewer should be prepared to change the order of questioning during the interview;
- Interview questions should be formulated in a way they enable the interviewer to answer the research questions;
- Leading questions should be avoided.

In order to gain a qualitatively good data set out of the interviews the author has chosen to perform not more than one interview per day. Hereby the results have been documented the same day as the interview took place. Respondents have not been recorded during the interview with the idea that it might restrict their '*freedom of speaking*'.

The interview guide is attached to the report to strengthen the dependability of the research (Bryman and Bell 2011). Besides the semi-structured interview another sources of primary data results from e-mail contact with industry actors such as ground-handling firms.

Besides the abovementioned primary data, secondary data in the form of annual reports, books, industry statistics which have been published by governing bodies such as IATA, ICAO, and Avinor and a broad range of scientific articles has been used as input for the research.

2.3 Data reliability and validity

Even though Bryman and Bell (2011, p. 394) are stating that "reliability and validity are important criteria in establishing and assessing the quality of research for the quantitative researcher", also for qualitative research data reliability and validity should be taken into account. Here reliability "refers to the consistency of a measure of a concept" and validity refers to "the issue of whether or not an indicator (or set of indicators) that is devised to gauge a concept really measures that concept" (Bryman and Bell 2011, p. 158).

During the research all what possible could be done to maintain the reliability and validity of the research has been put into practice. Hereby objectivity during the interviews was one of the main concerns since respondents might perhaps provide answers in favor of their own interest. Another concern has been the accuracy of industry statistics. The air freight industry is a vast and fast changing industry making it difficult, sometimes impossible to obtain the latest up-to-date industry statistics. Most recent industry statistics have been used in order to provide the most reliable overview of the industry even though some might be dated from a couple of years ago.

2.4 Structure of the thesis

The structure of the written report is to a large extend based on a developed conceptual theoretical framework. The structure and content of the conceptual theoretical framework together with the structure of the thesis will be discussed next.

2.4.1 Conceptual theoretical framework

The structure of the thesis is based on the developed conceptual theoretical framework which is displayed in figure 2-2. The conceptual theoretical framework consists of

attributes which, according to the scientific literature and common sense influence the demand for air freight services. Besides the influence of the attributes on the demand for air freight services, it also shows the interaction between the attributes itself. The attributes are selected after an extensive literature review regarding air freight services and related topics. Furthermore the framework is closely linked to the developed research questions, i.e. the results of the research questions should provide inside knowledge on the influence of each attribute on the demand for air freight services. The different attributes will be shortly introduced next.

As depicted in the conceptual theoretical framework a diversity of attributes affects a firm's demand for air freight services. A case study performed by Leinbach and Bowen (2004, p. 299) shows that "the diversity of air cargo usages is related to several aspects of firm structure and operation". Their findings suggests that firms aspects such as product cycle, internationalization, localization, product type, and other factors such as materials management strategy explain for a large extend a firm's air freight usage. These attributes are included in the conceptual theoretical framework in the box '*firm's business model'*.

Zhang and Zhang (2002) are discussing the impact and implications of liberalization on the structure and efficiency of the air freight industry. In their discussion they include the role of air services agreements, freedoms of the skies and regulatory bodies such as IATA and ICAO. The authors conclude that the international regulatory framework might be an important constraint in the future growth of the air freight industry. These attributes are included in the box '*international regulations'*. Furthermore Ishutkina and Hansman (2008, p. 18) identify the important role of local governments since "its policies can influence both economic and air transportation attributes through regulations and infrastructure investments". These attributes are included in the box *'national regulations'*.

The mutual interaction between air transportation and economic activity is discussed by Ishutkina and Hansman (2008, p. 1) stating that a regions economic activity "generates the need for passenger travel and freight and drives the demand for air transportation services". This is a result of air transportation that is providing "employment in the aviation sector and creates wider socioeconomic benefits through its potential to enable certain types of activities in a local economy" (Ishutkina and Hansman 2008, p. 1). The

impact of economic activity on the demand for air freight services is included in the conceptual theoretical framework in the box *'economic activity'*.

The increased distance between upstream suppliers, focal firms and downstream end-customers resulting from the internationalization of trade have been increasing the need for transportation modes which are able to cover long geographical distances relatively quickly. Hereby putting not too much stress on the transportation costs (Yamaguchi 2008). Air freight services are more often the preferred mode of transportation in order to cover the increased distance between networks of production and consumption. Factors affecting the level of international trade and thereby indirectly the demand for air freight services are included in the box '*international trade'*.

The attractiveness of the air freight supply chain is partly influenced by the quality, capacity and accessibility of infrastructure needed to accommodate the air freight supply chain. Here infrastructure does not only refer to air freight service related facilities such as airports and ground handling facilities but also the network of connecting surface transportation infrastructure in order to facilitate door-to-door shipments. Those attributes are included in the box *'infrastructure'*.

The role of the design of a firm's supply chain network on demand for air freight services is not specifically discussed in the scientific literature. However sources like Lee (2004); Hummels (2007) and Capineri and Leinbach (2006) are discussing the essential role of logistics and transportation networks as supporting infrastructure of international trade and agile supply chains. The interaction between the design of a supply chain on demand for air freight services is included in the box '*supply chain management*'.

The attractiveness of air freight services is to a large extend set by the quality provided by the supply side of air freight services i.e. airlines, airports, freight forwarders, and so on. Even though scientific literature suggest that economic efficiency is becoming more important, still a large emphasis regarding the attractiveness of air freight services is on the quality provided by the sector (Park, Choi, and Zhang 2009). The influence of the attractiveness of air freight services on the demand for it is included in the box '*supply or air freight services'*.

Increasing end customer requirements such as shorter lead-times and high levels of flexibility are driving manufacturing firms to become more agile in their supply chains. Due to specific attributes of air freight services such as the short lead-times and high level of flexibility, it might enable firms to satisfy customer requirements. The role of customer requirements on a firm's demand for air freight services is added in the box '*end-customer preferences*'.

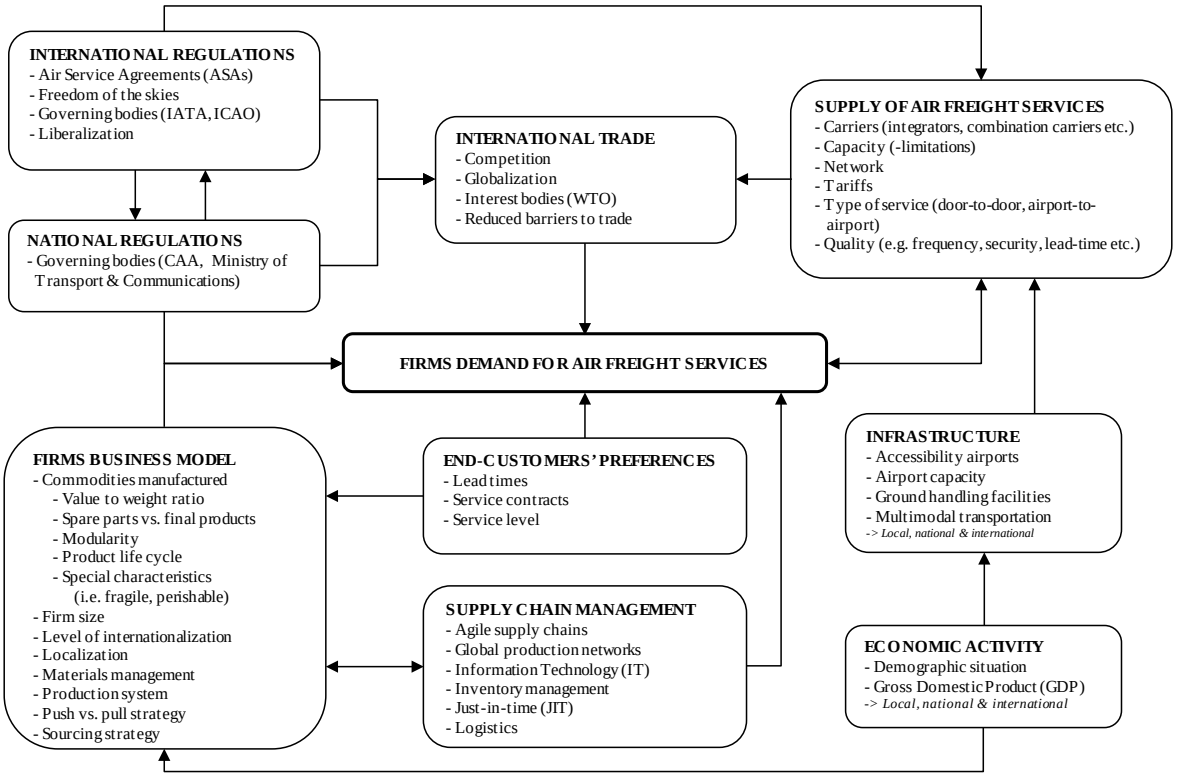

Figure 2-2: Conceptual theoretical framework of the research.

The multiple case study analysis will mainly focus on the role of the firm's business model, supply chain management strategy, and end customer preferences on the demand for air freight services. '*Environmental'* factors such as regulations and international trade will be discussed according to theory obtained from scientific literature to provide a framework in which modern firms operate.

2.4.2 Structure of the thesis

The structure of the thesis will be divided into five main parts which in total includes nine chapters, as discussed below.

- *Part I*: Introduction

The first part of the thesis will cover *Chapter 1* which provides an introduction to the research topic including the research questions and delineation of the research. Thereafter *Chapter 2* will shed light on the methodology of the research including the research design and the data collection methodology.

- *Part II*: Theoretical framework

The second part of the thesis will covers the theoretical framework of the research which is covered in *Chapter 3.*

- *Part III*: The air freight industry

The third part of the thesis will provide a detailed overview of the air freight industry and all its aspects. First *Chapter 4* will provide an overview of the international, Norwegian and local (Møre og Romsdal) air freight industry where *Chapter 5* covers the national and international regulatory framework which influence the air freight industry. *Chapter 6* will provide a description of the air freight supply chain including the physical flow of goods and information exchange between air freight supply chain actors.

- *Part IV*: Case study results and analysis

The fourth part of the thesis will display the results of the multiple case study representing *Chapter 7.* First the case study design and set-up will be discussed followed by a short introduction of the case study firms. Finally an extensive analysis will be provided discussing the results of the case study research.

- *Part V*: Conclusion and reflections

The final part of the thesis will provide the reader with reflections on the research. First *Chapter* 8 will provide the answers and reflections on the research questions. *Chapter 9* will give the conclusion of this research followed by its limitations and advise for further research.

3. Theoretical framework

Chapter three will elaborate the relevant theories applied in the research. The note should be made that seen the extensive scope of the research a large number of theories could be applied. However since the main focus of the research will be to explain demand for air freight services based on supply chain management theory, other relevant theories will not be elaborated in the theoretical framework. If needed to explain certain phenomena, other relevant theories will be shortly discussed in the main body of this thesis.

3.1 Supply chain management

According to Cooper, Lambert, and Pagh (1997) supply chain management is a relatively young term in scientific literature and appeared for the first in 1982. A common used definition of supply chain management has been developed in 1994 by members of the Global Supply Chain Forum and states that "supply chain management is the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders" (Lambert, Cooper, and Pagh 1998, p. 1).

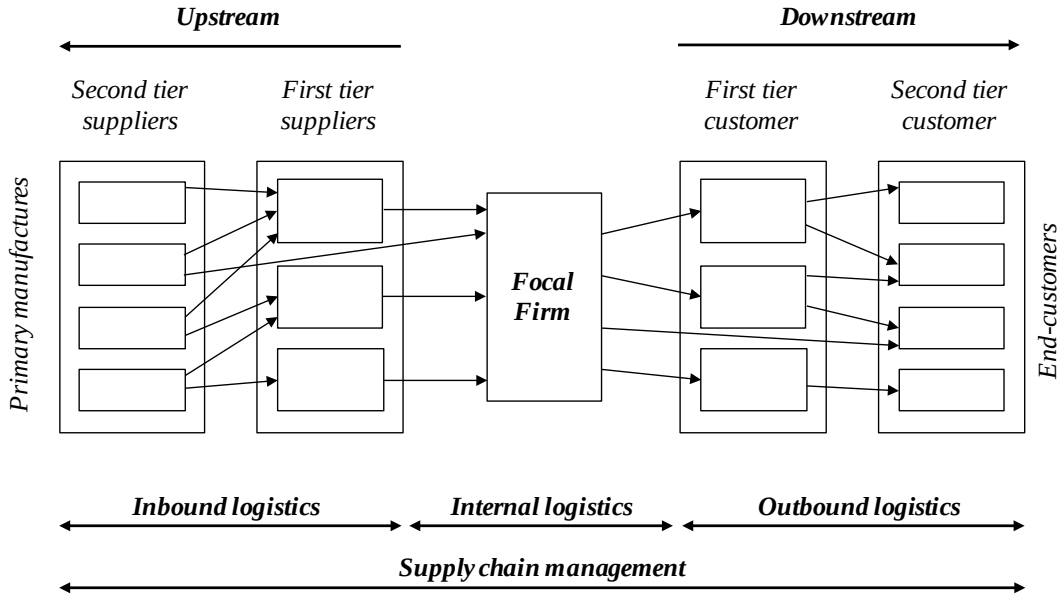

Figure 3-1: The supply chain network (compiled by author based on Harrison and van Hoek (2008, p. 9).

As can be seen in figure 3-1 "the focal firm is embedded within the chain, and its internal processes must coordinate with others that are part of the same chain" (Harrison and van Hoek 2008, p. 9). Following Lambert, Cooper and Pagh (1998) "the success of a single business will depend on management's ability to integrate the company's intricate network of business relationships". This expression indicates that networks of companies and the management of these networks are essential for a business to be successful. The network of businesses is depicted in figure 3-1 as the network between upstream suppliers, the focal firm, and downstream customers. Here the physical material flow is initiated upstream at the primary manufactures and flows in the direction of the end-customers passing several value adding processes. The information flow is bidirectional since information is exchanged between upstream and downstream supply chain partners and vice versa.

According to Lambert, Cooper and Pagh (1998) "supply chain management offers the opportunity to capture the synergy of intra- and inter-company integration and management. In that sense, supply chain management deals with total business process excellence and represents a new way of managing the business and relationships with other members of the supply chain". This is confirmed by Leinbach and Bowen (2004, p. 301) who are stating that the purposes of supply chain management is to "aim for improvement in logistics performance including greater reliability, smoother flow through the chain, and more efficient connections between the various links in the chain and second, to realize the lowest possible cost for the chain as a whole".

Managing supply chains effectively can be a challenge due to for example short product life cycles, globalization, outsourcing, and an increasing level of product variation (Lee 2002). Lambert, Cooper and Pagh (1998, p. 5) in addition state that "the key element of managing the supply chain is to have an explicit knowledge and understanding of how the supply chain network structure is configured". One has to understand that there is no supply chain strategy that is suitable for all firms; instead the right supply chain strategy for a firm is dependent on number of factors. Lee (2002) states that a supply chain strategy needs to be tailored to meet the specific needs of the end customer and that products with stable or unstable demand should not be management in the same manner.

3.1.1 Service supply chains

By applying the supply chain management theory in explaining the role of air freight services in a firm's supply chain management strategy the distinction towards the service supply chain should be made. Services have become more dominant in economies and outpacing the importance of manufacturing. Hereby services have a specific set of characteristics different from manufactured goods. The main distinctive characteristics of services compared to manufactured goods include (Zhou, Park, and Yi 2009; Sampson 2000):

- The delivery of service products is *labor intensive*. Due to the large number of required manual processes (due to non-standardized products) the interaction of resources in the form of employees is required;
- The output of a service tend to be *heterogeneous* due to the non-standardized input;
- Services are *intangible*. Services cannot be stored, handled or transported. The intangible characteristics of services shift management focus away from inventory management into capacity flexibility management. Hereby unsold services cannot be (re)sold again;
- *Simultaneous production and consumption*. A service is produced and consumed at the same time without any lead-time in between which can serve as a buffer against demand uncertainty;
- *Customer-supplier duality*. In service supply chains the customer fulfils both the function of customer (receiving the output of the service process) and of supplier (providing the input for the service process).

Due to the above mentioned distinctive characteristics the definition of supply chain management used in the manufacturing industry does not completely fit in services industries. A revised definition of supply chain management regarding service supply chains is provided by Ellram, Tate and Billington (2004, p. 25) which states that: "supply chain management is the management of information, processes, capacity, service performance and funds from the earliest suppliers to the ultimate customer".

The distinctive characteristics of services influence the management of service supply chains. In conventional manufacturing supply chains goods flow from upstream suppliers to downstream customers making it unidirectional. Due to customer-supplier duality in

service supply chains production flows also from downstream customers to upstream suppliers making it bidirectional. In manufacturing supply chains input flows into the manufacturing process representing monetary costs, where in service supply chains the customer provides the input resulting in very low variable costs. Thereby as mentioned the function of inventory to handle demand uncertainty is absence in service supply chains. Therefore flexible capacity is essential in the success of a service supply chain (Ellram, Tate, and Billington 2004; Sampson 2000).

The service supply chain theory is relevant for this research because air transportation is classified as a typical service. Secondly an important sector of the service industry is the provision of service to end customers in the form of maintenance, repairs and service of equipment. Typically those spare- and service parts are transported via air freight services.

3.1.2 Agile supply chains

In recent years supply chains have become more and more exposed to sudden and unexpected market changes. “Turbulent and volatile markets are becoming the norm as life-cycles shorten and global economic and competitive forces create additional uncertainty” (Christopher 2000, p. 37). These market trends are accompanied by natural disasters, terrorism, wars, and epidemics such as the terrorist attack on New York in 2001, the strike of Californian dockworkers in 2002, and the SARS epidemic in Asia in 2003 (Lee 2004). “To become more responsive to the needs of the market requires more than speed, it also requires a high level of manoeuvrability that today has come to be termed agility” (Christopher 2000, p. 37). Hereby “the essence of an agile supply chain is its ability to respond quickly and efficiently to a volatile marketplace” (Jones-Mason and Towill 1999, p. 67).

The instantaneously fulfilment of demand is a key in today markets in order to keep customer service levels high. “The key characteristic of an agile supply chain is the lead time each player has to wait between receiving a demand from his customer and delivery from his supplier. This lead-time dramatically affects the dynamic response characteristic of a supply chain” (Jones-Mason and Towill 1999).

Lee (2004, p. 6) provides six rules of thumb on how agility can be built into supply chains:

- Provide data on changes in supply and demand to partners continuously so they can respond quickly;
- Develop collaborative relationships with suppliers and customers so that companies work together to design or redesign processes, components, and products as well as to prepare backup plans;
- Design products so that they share common parts and processes initially and differ substantially only by the end of the production process;
- Keep a small inventory of inexpensive, non-bulky components that are often the cause of bottlenecks;
- Build a dependable logistics system that can enable your company to regroup quickly in response to unexpected needs;
- Put together a team that knows how to invoke backup plans.

In addition, agile supply chains are highly relevant concerning the supply chain management of spare- and services parts. Here demand is highly unpredictable and the essence of quick response time is high because of expensive break-down time. In addition Lee (2004) is stating that often supply chains are considering speed against costs, but agile supply chains are responding both quickly and cost efficient. In the end it is all about getting the right product, at the right price, at the right time to the end customer. This is recognized by Capineri and Leinbach (2006, p. 27) stating that “cost, value and speed are not tradeoffs but objectives in their own right”.

3.1.3 Logistics

The distinction between supply chain management and logistics is often defined as unclear. Not uncommon the two terms are used synonymous which is incorrect. By comparing both definitions one could see clearly a distinction between the two practices. As stated by Lambert, Cooper, and Pagh (1998, p. 3) the Council of Logistics Management defined logistics as “that part of the supply chain process that plans, implements, and controls the efficient flow and storage of goods, services, and related information from the point-of-origin to the point-of-consumption in order to meet customer’s requirements”.

Lambert, Cooper, and Pagh (1998, p. 2) state that logistics can be seen as phenomenon within supply chain management. Logistics management includes, but is not limited to "the management of materials and information flows across the supply chain". The same function of logistics is recognized by Harrison and van Hoek (2008) stating that logistics is the "task of coordinating material flow and information flow across the supply chain to meet end-customer needs". Supply chain management however has a much larger function of integrating, planning, controlling and managing cross-border business processes. In other words logistics is one of the key functions of an efficient supply chain management strategy.

4. The air freight industry

Chapter four will provide an introduction into the air freight industry and its characteristics, developments and statistics. The chapter is divided into three parts; the international air freight industry, the Norwegian air freight industry, and the local air freight industry in Møre og Romsdal.

4.1 The international air freight industry

The history of air freight takes off on November 7th, 1910. The first commercial freight flight, operated with a Wright Model B aircraft transported 200 pounds of silk with a value of US$ 800 from Daytona to Columbus, Ohio. During the past 100 years the industry changed significantly due to political, social, and technological developments. However, the air freight industry remained a side-line of the airmail and passenger industry in the first half of the 20th century (Krovat 2011). The fast development of the air freight industry started after World War II (WWII) driven by two factors. First off all the technological development of aircrafts and related aviation equipment during WWII such as jet planes and radar equipment. Secondly the large scale destruction and the resulting reconstruction of cities and industries after WWII increased demand for air freight services dramatically. During the mid-1960s a range of new more cost efficient aircrafts where developed. The decreased operational costs increased the air freight industry even more. In the past decades the air freight industry has been growing strongly. Even though passenger revenues are still the most important source of income for airlines, the revenue resulting from air freight services is becoming more and more important for airlines (Efstathiou and Anderson 2000).

4.1.1 Drivers behind air freight

The international air freight industry has been strongly growing in recent decades. From 1975 to 2007 the freight tonne-kilometer (FTK) have been increasing from 19.370 million FTKs to 158.000 million FTKs (Kupfer et al. 2009). This trend is recognized by Leinbach and Bowen (2004, p. 299) stating that “between 1980 and 2000, the volume of international air freight traffic, measured in freight tonne-kilometer, grew fivefold”. The strong growth of the air freight industry can be explained by several factors.

First of all the introduction of the just-in-time (JIT) manufacturing philosophy has increased the need for fast modes of transportation like air freight services in order to facilitate quick deliveries into manufacturing processes. Suppliers are required to deliver the correct amount of components directly into the production lines of the manufactory. Hereby warehousing and storage costs can be eliminated from the production process resulting in an overall cost saving for the manufacturing company. Air freight is used to support the just-in-time deliveries of components into the production line. The increase in transportation costs compared to other modes of transport is minor compared to the costs of an idle production line (Leinbach and Bowen 2004; Button and Taylor 2000; Yuan, Low, and Tang 2010; Kupfer et al. 2009). The increased usage of air freight in just-in-time manufacturing processes is recognized by Leinbach and Bowen (2004, p. 301) stating that "the proliferation of just-in-time material management practices has helped to redefine air cargo for many firms from an emergency recourse to a regular feature of supply chain management strategies".

Secondly the shortening of product lifecycles has resulted in an increased demand for air freight services. Consumers are increasingly demanding in terms of the quality, innovation and availability of the products and services they are consuming. As stated by (Senguttuvan 2006, p. 8) "the modern consumer is no longer waiting for a new product for a year or so, therefore, the products are produced somewhere, but it becomes available in their own country within a short span of time". Due to this trend, producers are forced to invest in their product development in order to satisfy consumer demand. Producers need to launch more innovative products in a relatively short period of time, without compromising on the quality of the products. Consequently, producers need to develop, manufacture and launch their products on the market in an increasingly short time (Yuan, Low, and Tang 2010; Chew et al. 2006; Aitken and Towill 2003). "The solution to the constraint of time is found in the inclusion of freight transport by air, justifying the increased costs of transport by the increased sales the product may generate by getting to the market faster" (Efstathiou and Anderson 2000, p. 30). In addition, Yamaguchi (2008, p. 653) is referring to the importance of air freight service in order for manufacturing firms to be able to introduce their products quickly onto the market and states that "air cargo services are an indispensable mean of logistics services in today's manufacturing. By expeditious and reliable transport service manufacturing sector could avoid risk of holding inventory as well as to penetrate into final markets quickly".

A third factor increasing the demand for air freight services is the increased level of internationalization of firms. The increased level of internationalization has extended geographical distances between the sourcing, production, and consumption of goods. Firms are sourcing their raw materials on a global scale, making the trade-off between increased transportation costs against cost savings due to lower prices of suppliers resulting from productivity gains and economies of scale. Thereby firms are also exploring the opportunity to increase revenues by distributing their products on a global market. The trend of internationalization has therefore accelerated the demand for air freight services since raw materials and end products need to be transported over larger distances (Leinbach and Bowen 2004; Efstathiou and Anderson 2000). The importance of air freight services in such a global environment is recognized by Boeing (2010, p. 11) stating that "air cargo is essential to global sourcing, manufacturing, assembling, and distribution of goods, which together account for much of the growth in air cargo traffic".

In addition Yuan, Low and Tang (2010) are indicating the increasing industry of high-value lightweight products such as pharmaceuticals and micro-electronics. "As much as 80-90 percent of their international movements are by air (Yuan, Low, and Tang 2010, p. 215).

On the supply side more fuel-efficient, larger wide-body aircrafts have reduced air freight tariffs about 3 percent annually, making air freight a more affordable mode of transport for transporting goods. The decline of tariffs has been supported by the increased liberalization of air freight services, which has increased competition and therefore has reduced tariffs (Leinbach and Bowen 2004; Yuan, Low, and Tang 2010). Furthermore Zhang and Zhang (2002, p. 275) mention that "streamlining business supply chains has made air cargo in general, and air express in particular, the fastest-growth area in the dynamic cargo sector". Finally firms increasingly recognize that the high costs of air freight services can be compensated with cost reductions in inventory, warehousing and packaging costs (Yuan, Low, and Tang 2010). The effect of the abovementioned factors makes that "airfreight is playing an ever-increasing role in the distribution systems of many companies" (Yuan, Low, and Tang 2010, p. 215).

4.1.2 Air freight as a mode of transportation

The role of air freight as a mode of transport is small compared to other modes of transport such as road, sea, and rail. Nowadays, air freight accounts only for 1 per cent in terms of the weight of transported goods, but in terms of value of goods it accounts for approximately 40 per cent of total world trade (David and Stewart 2010; Zhang and Zhang 2002). In general goods with high weights are transported via sea transportation and therefore statistics based on weight regarding international trade underestimate the economic importance of air freight transportation (Hummels 2007).

Despite the 'relatively' small share of air freight in global distribution, the importance of air freight as a transportation mode is large for global supply chain management. This is recognized by Kasarda and Green (2005, p. 459) stating that "air cargo enables nations, regardless of location, to efficiently connect to distant markets and global supply chains in a speedy, reliable manner". Thereby "between 1975 and 2004, air tonnage grew at 7,4 percent per annum, much faster than both ocean tonnage and the value of world trade in manufactures in this period" (Hummels 2007, p. 134). Table 4-1 provides the modal distribution of goods transport in the EU in tonne-kilometer (TKM) for 1995 and 2006. As can be seen the share of air transportation measured in tonne-kilometer has not gained much share between 1995 and 2006. The transportation mode road has been increasing strongly were rail shows a decrease. The share of transportation via sea has been relatively stable at approximately 37,5 percent.

Transportation mode	**1995**	**2006**
Road	42,1%	45,6%
Sea	37,6%	37,3%
Rail	12,6%	10,5%
Inland waterways	3,9%	3,3%
Oil pipelines	3,8%	3,2%
Air	0,1%	0,1%

Table 4-1: Modal distribution of goods transport in % TKM, EU-27 countries 1995 and 2006 (Eurostat 2009, p. 58).

According to Boeing (2010) the world air freight traffic will grow 5,9 percent per year over the next 20 years (2009-2029). Air freight measured in revenue ton kilometres (RTK)

will grow on average 6,0 percent annually resulting in an increase from 166.8 billion RTK's in 2009 to over 526,5 billion RTK's in 2029.

Zhang and Zhang (2002) predicts that the growth in the air express market will outpace the growth of the total air cargo market in future years because of the pressure of the just-in-time production system, the vertical integration of the logistics industry and the increasing trend towards the outsourcing of distribution activities. Thereby Gardiner, Ison, and Humphreys (2005, p. 393) mention that the freighter fleet will almost double over the next 20 years because "air cargo industry trends such as reduced passenger belly hold capacity on short and medium haul routes, a growing recognition of the profit potential of cargo by airlines and potential new security regulations governing belly hold cargo...".

Geographically, the domestic China and intra-Asia industries will continue to lead the world air freight industry with annual growth rates of 9,2 percent and 7,9 percent, respectively. Air freight growth rates in the Latin America-North America, Latin America-Europe and the Middle East-Europe will be approximately equal to the world average growth rate. The air freight industry in North America and Europe shows lower-than-average growth rates, caused by the maturity level of these markets. These two industries are predicted to have annual growth rates of 3,6 percent and 3,0 percent respectively (Boeing 2010).

4.1.3 Air freight commodities

Commodities transported by air freight services in general have a high value to weight ratio. This is recognized by a survey performed by Yamaguchi (2008, p. 654) regarding the value per kilogram of air freight imported and exported commodities in the US and Japan. Imported commodities by air freight services in these countries have an average value per kilogram between 97 US$ and 127 US$ where exported commodities by air freight services have an average value between 111 US$ and 139 US$ in 2006. Thereby Boeing (2008) is stating that "products that have a value to weight ratio of greater than US$ 16 per kg have a high likelihood of being carried by air".

Besides the high value to weight ratio, other characteristics of commodities transported by air freight services are "perishability (physical, but also more and more economic), high

value (security, carrying costs), high business process impairment value, low demand predictability, and compact physical characteristics (size, density)" (Cech 2004, p. 5).

But "the range of 'air-eligible' goods continues to widen as more firms look to the speed and precision of their supply chain management strategies as sources of competitive advantage" (Leinbach and Bowen 2004, p. 299). This is recognized by Cech (2004) who is stating that air cargo is no longer a premium mode of transport for urgent needed goods, highly perishable goods or for goods with a high intrinsic value. Instead "the trend from a premium market to a commodity market has widened the range of goods being transported" (Cech 2004, p. 5).

The breakdown of air freight commodities will vary according to the unit of analysis which is used. Also, the breakdown might vary in freight operations between different geographical regions. According to Morell (2011), the breakdown of air freight commodities in freight tonne-kms in 2007 was as followed:

Air freight commodity	**Breakdown**
High-tech products	27%
Capital equipment	19%
Apparel, textiles and footwear	17%
Consumer products	16%
Intermediate products	12%
Refrigerated foods	5%
Others	4%

Table 4-2: Breakdown air freight commodities worldwide in freight tonne-kms, 2007 (Morell 2011, p. 25).

The majority of the goods transported by air transport are high-tech products (27%), followed by capital equipment (19%) and apparel, textiles and footwear (17%). The share of commodities transported via air freight differs highly amongst geographical areas. Europe is mainly exporting capital equipment via air freight services where North America is mainly exporting high-tech products and capital equipment to Latin America, Europe, and Asia. Exports from Asia to Europe and North America are dominated by high tech products as well as the intra-Asian air freight traffic. The most divergent market is the air

freight market between Latin America and North America which is dominated by refrigerated goods (Kupfer et al. 2009).

For those commodities with high value to weight ratios or which are perishable, transportation by air freight is often the only feasible long-distance transportation solution (Ishutkina and Hansman 2008).

4.1.4 Air freight networks

Different than passenger transport, air freight travels from production to distribution and consumption centres, resulting in unidirectional networks. This means that air cargo travels in only one direction as trade volumes dictate (Grosso and Shepherd 2010). This unbalance in goods flow often forces air cargo carriers to make more than one stop on their route, in order to make the total route flown profitable. Freight has to be collected and deplaned along the route on a variety of airports. The fifth and seventh freedoms of the air are therefore important for a flexible planning of air freight services, since they provide foreign airlines the rights to pick up goods abroad and deplane the cargo into another foreign country without going through the home country (see paragraph 5.1.2 for a detailed overview of the freedoms of the air).

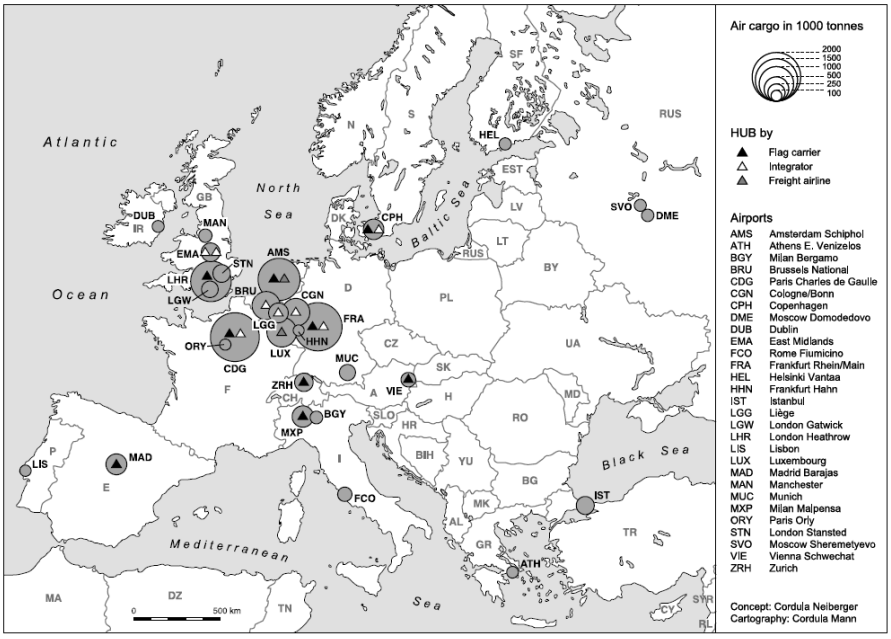

Figure 4-1: Main European air cargo airports 2005 (Neiberger 2008).

Air freight transported onto passenger planes faces the disadvantage of the network structure of passenger carriers. “Cargo tends to move from manufacturing to distribution centers, or from production to consumption centers, while passengers tend to travel to and from centers of commerce, production and leisure” (Zhang and Zhang 2002, p. 280). Hereby cargo in the form of raw-materials, components and sub-assemblies also tends to move between manufacturing centres. The reason for this flow is to capture advantages of specification, low labour costs and just-in-time inventory management practices (Senguttuvan 2006).

The network of destinations of a passenger carrier is developed to comfort passenger requirements. The often used hub-and-spoke system of passenger airliners is not the most optimal for air cargo traffic which “is focussed only on a few flows that are based around the centers of production and consumption. These flows are best met by substantial capacity on direct flights” (Zhang and Zhang 2002, p. 281). In addition “a large proportion of freight from the regional airports is not flown to the hub but transported by road to the hub” (Neiberger 2008). This is often referred to the term ‘*air trucking*’. Another driver behind this air trucking phenomena is the capacity of regional and local airports. Due to different types of aircrafts used, goods have to be packed on relatively small pallets at the regional airports and in addition repacked at the hub airport onto larger pallets to provide an optimal load distribution on the larger aircrafts. To avoid this unnecessary repacking, air trucking often replaces air transportation. An overview of the main cargo airports in Europe in 2005 is displayed in figure 4-1.

The destinations of passenger networks might not attract shippers of freight because the destinations do not match the locations of their supply chain partners. This accounts especially for small network carriers who have limited destinations and a low frequency of operating flights.

The imbalance of air cargo flows between regional markets differs per market as can be seen in figure 4-2. In 2008, the export/import tonnage ratio[3] from Europe to China was 1:2.6 where the imbalance from the USA to China was 1:3.1. There was no imbalance between Europe and the USA, where the ratio is 1:1. The largest imbalance is found from

[3] Export/import tonnage ratio: in the case of the imbalance from Europe to China which is 1:2.6; for every tonne exported from Europe, 2,6 tonnes are imported back via air freight services (Kupfer et al. 2009).

Europe to the Middle East, with an imbalance of 9.6:1 which is mainly caused by the booming economy in the Middle East. (Kupfer et al. 2009).

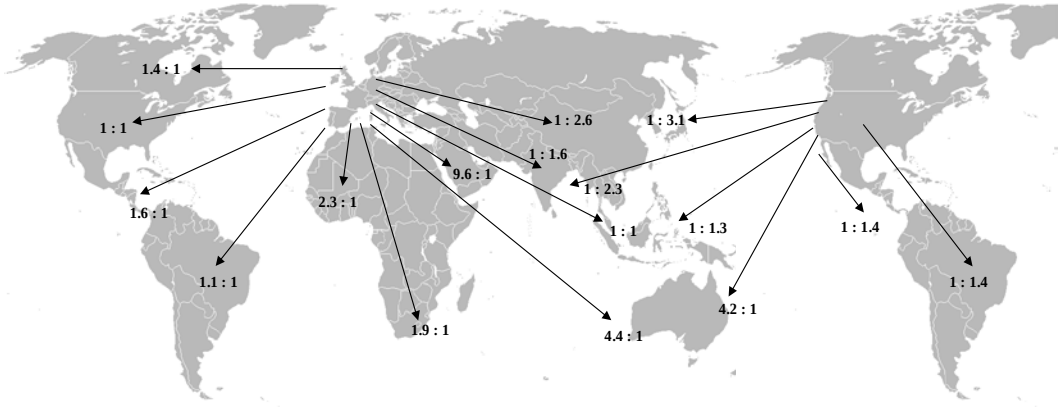

Figure 4-2: Export/import air freight ratio 2008 (compiled by author based on Kupfer et al. (2009).

Another drawback is the timing of passenger flights. Passengers normally prefer to travel in the morning or early evening, whereas air freight 'prefers' to be transported overnight, so it can be further transported to the end customer the next day in the early morning.

4.1.5 Type of carriers

A number of different carriers are operating in the air freight industry, as indicated by Doganis (2002, p. 304) "historically, the looser regulations of air freight services compared with that of passenger services has led to the emergence of a fairly heterogeneous industry with several different key players". Table 4-3 shows the share in million tonne-kms of the key carriers on the international air freight industry in 2008.

Carrier	***Freight (tonne-kms (m))***	***% total***
Freighter flights of combination carriers	74.071	44,8%
Passenger flights of combination carriers	65.364	39,5%
Integrators	13.133	7,9%
Freighter-only airlines	12.745	7,7%
Total international	***165.313***	***100%***

Table 4-3: International freight per type of carrier in million tonne-kms, 2008 (Morell 2011, p. 73).

The first group of carriers are the '*combination carrier*s'. Combination carriers are "conventional scheduled airlines which transport both passengers and cargo" (Doganis

2002, p. 304). Combination carriers provide in general only airport-to-airport services and are operating three kinds of services. First, there are the scheduled passenger flights which carry freight in the cargo compartment located in the lower deck of the aircraft. Examples of such carriers are SAS, British Airways and Cathay Pacific. On these scheduled passenger flights, passenger revenue is still significantly larger than the revenue resulting from carrying air freight in the cargo compartments in the lower deck. Following Zhang and Zhang (2002, p. 281) passenger revenues account for approximately 70% for those airlines. Secondly, there are carriers who provide scheduled all-cargo services. Third, there are combi aircraft carriers. Those carriers operate aircrafts where cargo is carried both on parts of the main upper deck and in the cargo compartments in the lower deck. "Combi aircraft tend to be used on routes where the demand for air freight is substantial while that for passengers is relatively thin" (Doganis 2002, p. 304).

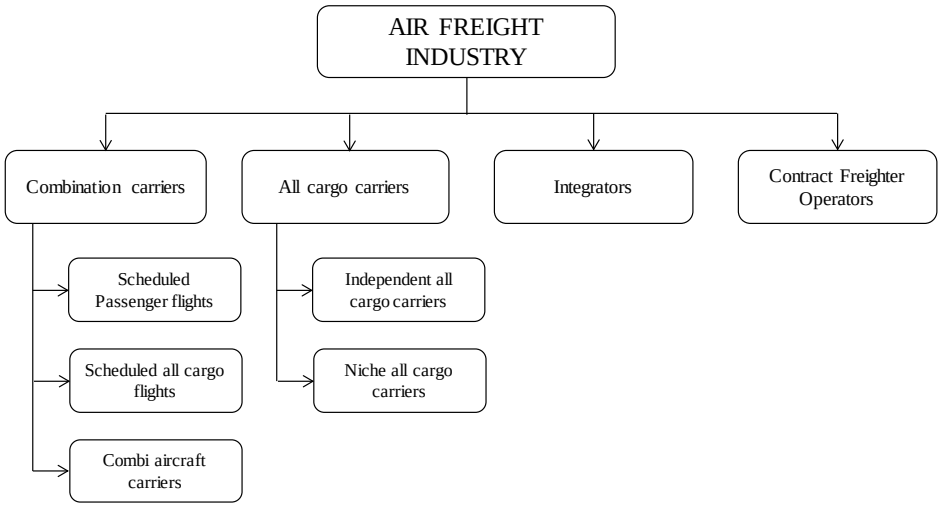

Figure 4-3: Types of carriers (compiled by the author based on Doganis (2002).

The second group of carriers are the '*all-cargo carriers*'. Those carriers are operating both scheduled as ad hoc charter services. Only a small share of air freight is carried by these all-cargo carriers. Most of those carriers did struggle to survive the fuel crisis in the 1970's and many of them have been taken over by integrators. The two main all-cargo carriers nowadays are Cargolux and Nippon Cargo. "Both of these fly primarily scheduled networks but also offer aircrafts for ad hoc charters or for leasing" (Doganis 2002, p. 304). Also all-cargo carriers are operating on an airport-to-airport network base.

The third group of carriers are '*integrators*'. Integrators are providing door-to-door services. Such services "requires the provision of road trucking for collection and delivery of freight" (Doganis 2002, p. 305). The two largest integrators in the international air freight industry are Federal Express (FedEx) and United Parcel Services (UPC). Two medium sized integrators are TNT and DHL (Zhang and Zhang 2002). Integrators are able to provide services with short lead-times and high reliability by using multimodal transportation networks. Integrators "owning and operating their own aircraft of different sizes, surface transportation equipment such as trucks, and automated handling and storage facilities" (Grosso and Shepherd 2010, p. 10). "Integrators connect the entire air freight chain for the transport of parcels in one enterprise" (Neiberger 2008, p. 250) . This might explain the integrators success since transaction costs of contracting external parties are abolished, process innovations can be penetrated with relative ease, and high levels of dependability are provided due to guaranteed delivery times (Neiberger 2008).

The last group of carriers are the '*contract freighter operators*'. Those carriers operate all-cargo services mainly on behalf of other airliners on a wet-lease contract basis. Following Doganis (2002, p. 306) carriers operating on such an contract basis "provide great flexibility in adding or reducing cargo capacity, and the low-cost structure of a specialist such as Atlas means that this capacity can be provided at rates 30 per cent more below the airlines' own costs of providing such capacity".

In recent years the full freighter industry has been significantly increased. Following (Kupfer et al. 2009, p. 2) the increase resulted from "insufficient freight capacity linked to more severe security regulations aboard passenger planes, a tendency towards consolidation and scale increase, and the important imbalance between some incoming and outgoing air cargo flows".

4.1.6 Aircrafts and their limitations

Basically all freight is transported with three types of aircrafts namely passenger aircrafts, combi aircrafts and freighter aircrafts.

- ***Passenger aircrafts***

Freight carried on passenger aircrafts is generally located in the lower deck compartments of the airplane, also referred to the '*belly hold*' compartments as can be seen in figure 4-4. Since those airplanes are designed to carry passengers only limited capacity for air freight is available. Table 4-4 shows the typical payload, volume and density for the lower deck freight for several common used passenger aircraft types.

Type of passenger aircraft	***Payload with full pax load (t)***	***Volume for cargo (cu.m)***	***Max. density (kg/cu.m)***
Airbus A320	1.0	3.6	277.8
Boeing 737-800	3.6	28.0	128.6
Airbus A330-300	15.0	80.2	187.0
Boeing 767-300	16.5	63.0	261.9
Boeing 747-400	20.0	73.4	272.5
Airbus A380	20.0	68.0	294.1

Table 4-4: Payload, volume, and density for lower deck freight of passenger aircrafts in tonnes (Morell 2011, p. 132).

These payloads may differ per airline regarding their seating density, passenger weights, estimated checked baggage and if the cargo is bulk loaded or loaded via lower deck containers (Morell 2011, p. 133).

Transporting freight on the lower deck of passenger flights faces in general the following difficulties according to Morell (2011, p. 133):

- No accommodation of large cargo;
- Uncertain available volume;
- Flight timing, frequency and destination.

The maximum size of one single piece of cargo is dependent on the available space in the lower deck and on the dimensions of the cargo loading door of the aircraft. Concerning the Boeing 737 series aircraft, all 737's have a forward cargo door size of 1,30m x 1,22m (C x B in figure 4-4) and a clear opening of 0,89m x 1,22m (A x B in figure 4-4). The aft cargo door size measures 1,22m x 1,22m (C x B in figure 4-4) and has a clear opening of 0,84m x 1,22m (A x B in figure 4-4). This means that the maximum size of cargo transported is

dependent on the clear openings of the cargo compartments. Unless air cargo is modular or easy to de-assemble, large items are in practice not suitable for air freight.

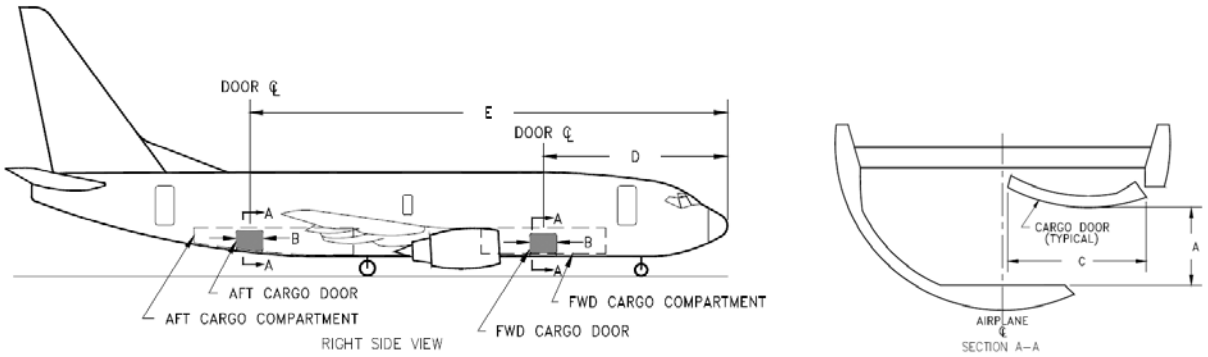

Figure 4-4: Door clearances lower deck cargo compartments Boeing 737 series (Boeing 2007).

The exact amount of volume or payload which is available onto passenger flights is dependent on a number of variables, and therefore highly uncertain. The available payload is dependent on the weight of fuel needed for the flight sector. The amount of fuel needed is normally determined at the day of the flight when operational variable conditions like airport temperature, routing and headwinds are known.

In addition the number of passengers and their checked baggage containers are reducing the available payload for cargo on passenger flights. The passenger load is uncertain upon several minutes before departure. Even though cargo bookers are usually working with pre-estimated passenger numbers, the payload available for cargo on passenger flights is known on its earliest the day before departure. Third air freight transported onto passenger planes faces the disadvantage of the network structure of passenger carriers (as discussed in paragraph 4.1.4).

- ***Freighter aircrafts***

Freighter aircrafts can be either converted passenger aircrafts or newly produced aircrafts. According to Morell (2011) about 50 percent of all freighter aircrafts have been converted from passenger aircrafts. Passenger aircrafts tend to retire after 18 to 20 years of service, are converted to freighter aircraft and operate for a further 15 to 20 years as freighter aircraft. The type of freighter aircraft operated by airlines is partly dependent on the intended use. For example “the longer range with full payload that a new freighter might offer may not be necessary for an airline that seeks to consolidate loads by operating multi-

sector routings" (Morell 2011, p. 135). And fleets of integrators such as UPS and FedEx consist mainly of old low capital cost converted aircrafts such as the Boeing 727 and Boeing 757. These aircrafts are mainly operated at night time flights resulting in a low level of daily utilization. An overview of the payload and range of some of the most used freighter aircrafts is shown below in table 4-5 (Morell 2011).

Type of aircraft	***Indicative payload (t)***	***Range (km)***
*Boeing 757-200F**	27	6.051
*Douglas DC8-61F**	40	3.982
*Airbus A300F**	54	5.378
Boeing 767-300F	54	5.785
Airbus A330-200F	64	7.400
McDonnell Douglas MD-11F	90	7.222
Boeing 777F	103	9.065
Boeing 747-800F	154	8.130

Table 4-5: Indicative payload and range freighter aircrafts (Morell 2011, p. 142)[4].

Combi-aircrafts can carry both freight and passengers on the main deck. Only between 150 of those combi-aircrafts have been manufactures and they represent a minor share of the air freight market.

4.1.7 Booking of air freight services

From the survey performed by Nordang and Grimsbo (2000, p. 25) it turns out that air freight services in Norway are mainly purchased via freight forwarders and that there is only a moderate level of contact between airliners and the actual product owners. Their survey showed that 62 percent of the air freight is booked through freight forwarders and only 3 percent direct by the product owners. The remaining is booked by integrated companies (28%) and others (7%). This is recognized by Kristian Stokke, ground handler for SASCargo at Kristiansund airport Kvernberget who is stating that "approximately 90 percent of the air freight going out of Kristiansund Airport Kvernberget is booked through a handful of freight forwarders of which Bring Cargo, Kuehne + Nagel, and Panalphina are the three main agencies". Following Nordang and Grimsbo (2000) there may be several factors which could explain this observation; the firms only have modest freight volumes,

[4] * = out of production.

freight forwarders can offer better rates resulting from groupage, firms don't have the necessary skills and knowledge to make air freight an efficient solution in their supply chain and the preference of airliners to cooperate with freight forwarders.

The booking of the right amount of air freight capacity is a major challenge for shippers and especially for freight forwarders. Shippers and freight forwarders "acquire cargo space on a long term contract basis" (Chew et al. 2006, p. 1980). The long term contract basis is forcing freight forwarders to acquire air freight capacity based on long-term forecasts of their clients. Hereby demand uncertainty and the low accuracy level of long-term forecasts making the purchasing of the correct amount of air freight capacity a big challenge. In addition "freight forwarders have to pay for any unused space" (Chew et al. 2006, p. 1980) since reselling of unused capacity is not allowed by airlines. On the other hand, a lack of available air freight capacity will impact the service level of the freight forwarder towards the shipper. When possible the freight forwarder will need to book extra air freight capacity which comes at a higher price (Chew et al. 2006). To summarize, freight forwarders facing the economic trade-off between not selling the acquired air freight capacity and the cost of acquiring additional '*last-minute*' air freight capacity.

4.1.8 Air freight security and quality

The high quality level of air freight services is an important factor which has supported the strong growth of the air freight industry. Initially the high industry quality standards where set by the integrators. In the past integrators have been able to provide their service at such high quality levels because of their operating structure. The integrator is the supply chain director and physically operates and manages the complete door-to-door air freight supply chain in-house with its own assets such as freighter planes and trucks. Thereby "integrators also charged a premium price and were expected to match this with a high quality service" (Morell 2011, p. 42). Combination carriers have been struggling to meet the high quality standards set by the integrators mainly because of their size and more complicated way of operating. The air freight supply chain operated by combination carriers consists of a large group of other actors such as freight forwarders and cargo agents. In where the combination carrier is only responsible for the airport-to-airport physical carriage of the goods. This makes it more difficult to improve quality because of the alignment and cooperation needed from the large number partners (Morell 2011).

In the year 2000 the Cargo 2000 program has been developed by airlines with the support of IATA in order to improve the quality and service of the air freight supply chain. “By reducing the number of individual processes in the air cargo supply chain from 40 to just 19, Cargo 2000 is less labor intensive and improves the processes for managing shipments in a paperless environment” (IATA 2012). Thereby “by attracting both forwarders and airlines Cargo 2000 was designed to respond to the high service standards set by their integrator competitors” (Morell 2011, p. 42). Cargo 2000 nowadays includes “some 50 major airlines, freight forwarders, ground handling agents, trucking companies and IT providers at over 350 sites” (IATA 2012). The service level of the involved airlines has significantly increased due to the implementation of the Cargo 2000 program. “The percentage of shipments flown by airlines as planned (and booked) has risen from 53 percent in September 2004 to 90 percent in June 2009, still just short of the target of 96 percent” (Morell 2011, p. 43).

4.2 The Norwegian air freight industry

The demand for air freight services in Norway has been fluctuating in recent years as displayed in figure 4-5. The total freight volume has been varying between 92.266 tonnes in 2000 and 65.832 tonnes in 2009. In the year 2011, 86.767 tonnes of air freight has been handled at Norwegian airports, of which 56,6 percent accounted for export and 43,4 percent for the import of goods.

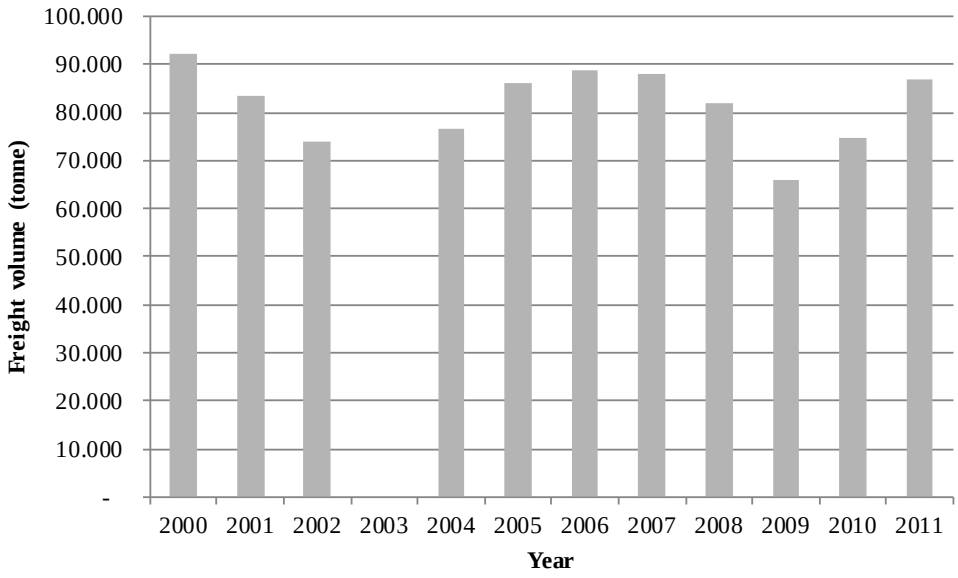

Figure 4-5: Airfreight demand Norway 2000-2011 (Avinor 2012).

“The World GDP is the sum of all goods and services produced in the world, representing the best single measure of global activity” (Boeing 2010, p. 14). A growth in the world GDP results in an increased demand for transportation services, revealing the opportunities for air freight services. However a note should be made when comparing relative GDP to air freight traffic. The share of services in GDP has increased from 53 percent in 1971 to nearly 70 percent in 2006. “The evolution of GDP is therefore more and more driven by the service sector and less by activities which may generate air cargo” (Kupfer et al. 2009, p. 11). Beside this drawback, the relation between GDP and air freight volume is widely discussed in the literature. Following Boeing (2010, p. 14) “world air cargo growth typically outpaces GDP growth by a factor of two”, which is also mentioned by Petersen (2007, p. 4) who stated that “the growth of international air freight has outpaced that of global GDP by a factor of 2,5 since 1980” and by Zhang and Zhang (2002, p. 277) who stated that air freight “has grown at between 1,5 and 2 times the rate of worldwide GDP growth”.

4.2.1 Airport network and freight traffic

The research will only focus on Norwegian commercial airports. The majority of airports in Norway are operated by airport operator Avinor. Only the airports Sandefjord, Torp; Skien, Geiteryggen; Notodden; Stord, Sørstokken; Rygge and Ørland are privately operated. Avinor operates 46 airports in Norway which facilitate both civilian and military services. The airports are divided into three scales of airports; large airports, regional airports, and local airports. Oslo airport Gardermoen is appointed as main hub. The geographical locations of the airports are displayed in figure 4-6.

Figure 4-6: Geographically display of the Norwegian airport network (Avinor 2011).

In 2011, a total volume of 86.767 tons of freight has been transported through the Norwegian airport network as displayed above. A substantial proportion of the total freight is transported via the large and regional airports and only a small proportion is transported via the local airports as can be seen in the tables 4-6 and 4-7.

Airport	***Freight 2011 (tonne)***	***Share***
Oslo, Gardermoen	69.956	80,6%
Bergen, Flesland	3.349	3,9%
Stavanger, Sola	3.197	3,7%
Trondheim, Værnes	1.836	2,1%

Table 4-6: Air freight volume Oslo and large airports 2011 (Avinor 2012).

Oslo airport accounts for 80,6 percent of the total air freight volume in Norway. In total 90,3 percent of the total air freight volume in Norway is handled by Oslo and the three large airports.

Airport	*Freight 2011 (tonne)*	*Share*
Trømso, Langnes	2.017	2,3%
Bodø	1.148	1,3%
Svalbard, Longyær	808	0,9%
Ålesund, Vigra	704	0,8%
Kirkenes, Høybuktmoen	515	0,6%
Harstad-Narvik, Evenes	438	0,5%
Kristiansand, Kjevik	330	0,4%
Molde, Årø	325	0,4%
Alta	282	0,3%
Haugesund, Karmøy	245	0,3%
Kristiansund, Kvernberget	200	0,2%
Lakselv, Banak	101	0,1%
Bardufoss	52	0,1%

Table 4-7: Air freight volume regional airports 2011 (Avinor 2012).

The share of regional airports in the total Norwegian air freight volume accounts for 8,3 percent spread over 13 airports. The remaining 1,4 percent is handled via the 29 local airports. NB: the airports are divided into large, regional and local according to the presented annual traffic statistics of Avinor. A complete overview of the freight volume per airport is attached in appendix A.

4.2.2 Air freight commodities

According table 4-8 which is based on statistics from Statistisk Sentralbyrå (SSB), a total freight volume of 126.200 tonnes has been imported and exported in Norway in 2010. This figure does not correspond with the 74.588 tonnes provided by the freight statistics of Avinor in 2010. A possible explanation might be the fact that Avinor excludes airports which are not operated by them. However following Avinor (2012) those non-Avinor airports handled only 103 tonnes of freight in 2010.

Commodities	*Import*		*Export*	
	Tonne	*Share*	*Tonne*	*Share*
Animal and vegetable oils, fat, and waxes	-	-	200	0,2%
Chemicals and related products	1.700	4,9%	5.100	5,6%
Commodities and transactions	300	0,9%	-	-
Crude materials, inedible, except fuel	600	1,7%	100	0,1%
Machinery and transport equipment	13.300	38,1%	12.900	14,1%
Manufactured goods classified by material	6.600	18,9%	3.900	4,3%
Miscellaneous manufactured articles	10.000	28,9%	3.300	3,6%
Food and live animals	2.300	6,6%	65.800	72,1%

Table 4-8: Imported and exported commodities by air freight in Norway in 2010 (SSB 2011).

4.2.3 Market for airfreight

According to figure 4-7, a majority of the goods imported and exported in Norway are transported by ship (58,7 percent in 2010). Air transport as a mode of transport is not often used in Norway. In 2010 only 0,05 percent of the total freight volume in Norway has been imported and exported via air transport. Even though this small share, air transport as a mode of transport has increased during the last 30 years. In 1980 air transport accounted only for 0,02 percent of the total freight volume transported.

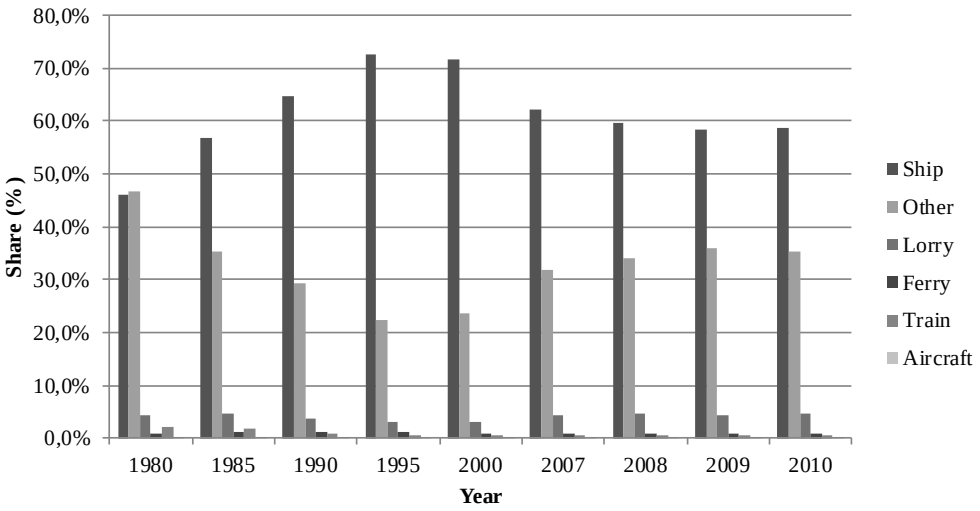

Figure 4-7: Import and export volume Norway by mode of transport 1980-2010 (SSB 2011).

4.2.4 Airlines

Airlines are an essential element of the air freight supply chain. Airlines providing the actual transporting services of goods between a set of airports. As described earlier there are several types of airlines in the air freight industry. The research will continue with the focus on two scheduled combination carriers namely Scandinavian Airlines and Norwegian. These two airlines are selected since they are the main carriers operating to and from the four airports in Møre og Romsdal.

- Scandinavian Airlines

Scandinavian Airliners (further: SAS) is the flag carrier of Norway, Sweden and Denmark. SAS was founded on August 1st, 1946 due to the established consortium between Svensk Interkontinental Lufttrafik AB, Det Danske Luftfartselskab A/S and Det Norske Luftfartselskap. The consortium was established in order to expand the international network of those three Scandinavian countries (SAS Group 2011). Thereby the consortium was divided into three subsidiaries; SAS Norway, SAS Sweden and SAS Denmark.

In Norway, SAS gradually gained control over the domestic market by acquiring the regional airline Widerøe Flyveselskap AS in 1997 and in 2001 the domestic airliner Braathens ASA, resulting in the subsidiary SAS Braathens. In 2007 the name finally changed in Scandinavian Airlines Norway (SAS Group 2011). SAS is operating their domestic scheduled services network in Norway with Boeing 737 series jet aircrafts. On behalf of SAS, the regional carrier Widerøe is operating regional short-haul domestic routes mostly in the form of Public Services Obligations (PSOs). The fleet of Widerøe consists of 33 Bombardier Dash Q8 series turboprop aircrafts.

In terms of revenue, scheduled passenger services accounts for 84,8 percent of the total revenue of the SAS Group in 2010. Revenue from air freight and mail services only accounts for 4,3 percent of the total revenue in 2010. Charter and other services accounts for the remaining 10,9 percent (SAS Group 2011).

Within the SAS Group, SASCargo is responsible for the marketing and sales of the cargo space in the SAS Group's aircrafts and offers services in air mail and freight to, from and within Scandinavia. SASCargo handled a total volume of freight and mail of 555.834

tonnes in 2010, resulting in a 5,4 percent decrease compared to 2009 as can be seen in table 4-9 (SAS Group 2011, p. 34).

Freight and mail, tonne km	***2010***	***2009***	***Change***
Intercontinental	535.352	392.139	36,5%
Europe	19.628	45.945	-57,3%
Intra-Scandinavian	586	651	-9,9%
Total international	***555,567***	***438,735***	***26,6%***
Denmark	12	11	9,9%
Norway	169	209	-19,1%
Sweden	86	134	- 36,1%
Total domestic	***267***	***355***	***-24,6%***
All Cargo	**0**	**148.524**	**-**
Total SAS Cargo	***555.834***	***587.614***	***-5,4%***

Table 4-9: Key figures SAS Cargo 2009-2010 (SAS Group 2011, p. 34).

- Norwegian Air Shuttle

Norwegian Air Shuttle ASA (further: Norwegian) is a low-cost carrier which operates scheduled services with in addition charter services. Norwegian is founded on January 22nd, 1993 and started operating regional air services in the Western part of Norway on behalf of Braathens. These regional routes where operated with seven Fokker F-50 commuter turboprop aircrafts with a capacity of up to 58 passengers.

Due to the merge of Braathens with SAS in 2001, whereby SAS started operating the regional routes under the subsidiary SAS Commuter (and later-on Widerøe), Norwegian lost their rights to operate the regional routes in Western Norway (Norwegian 2003). This resulted in a change of operating services, switching from regional services operated with turboprop aircrafts to domestic low-cost services within Norway operated with Boeing 737-300 narrow-body jet aircrafts in 2002. During later years the network expanded with a broad range of international routes and in 2008 the first intercontinental route to Dubai was established. Since 2007 Norwegian is updating their air fleet with Boeing 737-800 jet aircrafts, working towards a uniform fleet in 2014 (Norwegian 2010).

4.3 The local air freight industry in Møre og Romsdal

The county of Møre og Romsdal is located at the west coast of Norway and has a population of 256.133 inhabitants on January 1st, 2012. The population has increased with 4,1 percent compared to 2001 which is less than the 9,3 percent increase in the total Norwegian population in the same period. The population in Møre og Romsdal accounts for 5.2 percent of the total Norwegian population in 2012. Møre og Romsdal covers an area of 15.115 km2 and has a population density of 17 inhabitants per km2. The area covered by Møre og Romsdal accounts for 4,8% of the total land area of Norway (SSB 2011).

Four airports are located in the county of Møre og Romsdal as displayed in the table below.

Municipality	*Airport*	*IATA*	*ICAO*	*Operator*	*Airport Type*	*Runway (m)*
Kristiansund	Kvernberget	KSU	ENKB	Avinor	Regional	1.840 (07/25)
Molde	Årø	MOL	ENML	Avinor	Regional	2.110 (07/25)
Ørsta-Volda	Hovden	HOV	ENOV	Avinor	Local	2.625 (06/24)
Ålesund	Vigra	AES	ENAL	Avinor	Regional	2.314 (07/25)

Table 4-10: Airport overview Møre og Romsdal (Avinor 2012).

All four airports are operated by airport operator Avinor and are regional airports except for Ørsta-Volda airport Hovden which is defined by Avinor as a local airport. Ålesund airport is the largest of the four airports; handling 36,7 percent of all flights (landings and departures) in Møre og Romsdal and 55,8 percent of all the freight volume. Molde airport Årø is the second largest freight handling airport with 25,8 percent followed by Kristiansund airport Kvernberget with 15,8 percent. Local airport Hovden in Ørsta-Volda handled 2,7 percent of the total freight volume in Møre og Romsdal in 2011. In total the four airports in Møre and Romsdal handled 1,5 percent of all air freight movement in Norway in 2011. A complete overview of the traffic statistics is displayed in table 4-10.

In 2011, 53,6 percent of all freight has been exported and 46,4 percent has been imported in Møre og Romsdal. Notable is the minor amount of international import and export. Only 2 percent of all freight handled in Møre og Romsdal came or went across the Norwegian border. This might be the result of the measurement method applied by Avinor. The

destination, whether domestic or international, might be based on the first leg of the route which will be e.g. from Molde to Oslo. If the consignment is further transported internationally via airfreight from Oslo, according to this system of data measurement it will be a domestic consignment.

Airport	*Flights*	*Passengers*	*Freight (t)*	*Mail (t)*
Ålesund, Vigra	10.221	928.411	704	1,2
Molde, Årø	7.617	438.510	325	2.474
Kristiansund, Kvernberget	6.099	363.191	200	1,3
Ørsta-Volda, Hovden	3.930	101.384	34	0,1
Total Møre og Romsdal	***27.867***	***1.831.496***	***1.262***	***2.477***
Total Norway (Avinor)	***647.445***	***45.100.003***	***86.767***	***42.295***

Table 4-11: Traffic statistics airports Møre og Romsdal in 2011[5] (Avinor 2012).

4.3.1 Ålesund airport Vigra

Ålesund airport Vigra is located in the municipality of Ålesund and opened in 1958. The airport is the largest in Møre og Romsdal, handling 928.411 passengers in 2011. In terms of freight, the airport handled 704 tonnes of freight in 2011. The amount of freight handled has been reduced in recent years; in 2008 the airport handled 1.105 tonnes of freight.

Type of freight (tonne)	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Domestic import	535	566	451	451	450	217	186	230
Domestic export	462	522	526	626	638	494	498	454
International import	1	2	14	5	12	37	10	11
International export	1	4	1	2	5	2	3	9
Total freight volume	**999**	**1.094**	**993**	**1.084**	**1.105**	**750**	**697**	**704**

Table 4-12: Air freight volume Ålesund airport Vigra 2004-2011 (Avinor 2012).

4.3.2 Kristiansund airport Kvernberget

Kristiansund airport Kvernberget is located in the municipality of Kristiansund and opened on June 30th, 1970. In 1962, the airport commission (Flyplassutvalget) was initiated with

[5] Note: passengers including scheduled, non-scheduled, offshore, and transfer/transit passengers. Flights are including scheduled, non-scheduled, and freight operations.

the main goal to evaluate the future of the transport network as a backbone for Norway. Part of the research was focused on the development of an additional airport in Møre og Romsdal, besides Ålesund airport Vigra. In December 1964 the commission recommended to build nine new airports in Norway, of which two in Møre og Romsdal; respectively Kristiansund and Molde where Kristiansund airport Kvernberget was given first priority. The airport was built by the Civil Aviation Authority (Luftfartsverket) in close cooperation with the municipality of Kristiansund with a runway of 1920 meters (Avinor 2011). Braathens SAFE was the first airliner operating from Kristiansund airport Kvernberget with three daily flights to Oslo Fornebu. In 1971 88.246 passengers travelled via the airport, an amount that was reduced strongly in the years after due to the opening of Molde airport Årø in 1972 (Avinor 2011).

In the late 1970s the authorities designated Kristiansund airport Kvernberget as main base for oil exploration along the coast of central Norway. The designation was supported by the opening of parts north of the 62nd parallel of the Norwegian Continental Shelf for oil exploration in 1980 (Norwegian Oil Industry Association 2011). Helikopterservice started operating services between Kristiansund airport Kvernberget and oil drilling rigs in the Norwegian Sea. This increased activity related to the oil and gas industry contributed to a strong growth in the number of passengers travelling via Kristiansund airport Kvernberget. Where oil related passengers accounted for 26 percent of all traffic in 1997, it increased to 46 percent within ten years in 2007 (Avinor 2011).

Two airlines are operating scheduled services from Kristiansund airport Kvernberget; SAS and Widerøe. SAS operates a scheduled service to and from Oslo. This route is operated with Boeing 737 aircrafts. Widerøe operates scheduled services to and from Bergen, Molde, Stavanger and Trondheim. These routes are operated with Bombardier Dash Q8-series twin engine turboprop aircrafts.

From the four airports in Møre og Romsdal Kristiansund airport Kvernberget handled 15,8 percent of the total freight volume in 2011 in Møre og Romsdal. This results in 200 tonnes of freight of which 73,5 percent is domestic import. Furthermore the statistics showing a decrease of the freight volume since 2006 of 36,5 percent.

Type of freight (tonne)	2004	2005	2006	2007	2008	2009	2010	2011
Domestic import	191	224	208	201	177	165	152	147
Domestic export	48	63	69	69	60	64	49	50
International import	-	1	22	19	3	3	11	2
International export	-	-	17	2	-	-	2	1
Total freight volume	**239**	**289**	**315**	**291**	**241**	**232**	**215**	**200**

Table 4-13: Air freight volume Kristiansund airport Kvernberget 2004-2011 (Avinor 2012).

4.3.3 Molde airport Årø

Molde airport Årø is located in the municipality of Molde and opened on April 5th, 1972. The airport handled 127.113 passengers in 1985, which increased to 438.510 passengers in 2011. The airport is the second largest airport in Møre og Romsdal in terms of freight, with 325 tonnes of freight handled in 2011. The amount of freight handled has been fluctuating strongly in recent years as can be seen in table 4-14, and shows a strong decline since 2007 of 43,3 percent.

Type of freight (tons)	2004	2005	2006	2007	2008	2009	2010	2011
Domestic import	236	219	231	394	213	133	80	172
Domestic export	144	140	148	154	145	127	121	150
International import	-	4	23	23	24	3	21	-
International export	-	-	0	2	0	-	0	2
Total freight volume	**380**	**363**	**403**	**573**	**381**	**263**	**222**	**325**

Table 4-14: Air freight volume Molde airport Årø 2004-2011 (Avinor 2012).

When analysing the annual freight statistics in more detail, a strong increase in the import of freight in 2006 and especially in 2007 can be seen. This can be explained by the constructing of the offshore subsea gas processing plant Ormen Lange and the onshore process terminal Nyhamna at Aukra, which is located approximately 35 km outside the airport of Molde. The construction finished in the middle of 2007 and production started in September 2007 (Statoil 2012).

Four airlines are operating scheduled services from Molde airport Årø. Both SAS and Norwegian are operating services to and from Oslo. These routes are operated with Boeing

737 aircrafts. Furthermore Widerøe is operating scheduled services to and from Kristiansund and Bergen. These routes are operated with Bombardier Dash Q8-series twin engine turboprop aircrafts. Helitrans (in charge of Krohn Air) is operating a scheduled service to Trondheim with small Jetstream 32 turboprop aircrafts.

4.3.4 Ørsta-Volda airport Hovden

Hovden airport in Ørsta-Volda is the smallest airport operated by Avinor in the county Møre og Romsdal. The local airport has experienced a strong growth in terms of passengers in the past 25 years. In 1985 the regional airport handled a total of 18.138 passengers, which increased to 101.384 passengers in 2011. The airport handles a small amount of freight annually, 34 tonnes in 2011. However the amount of freight handled shows a steady growth since 2004 as is displayed in table 4-15.

Type of freight (tons)	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Domestic import	14	18	21	26	23	22	25	23
Domestic export	3	4	4	7	6	10	11	10
International import	-	-	-	-	-	-	-	-
International export	-	-	-	-	-	-	-	-
Total freight volume	**16**	**22**	**25**	**32**	**30**	**32**	**36**	**34**

Table 4-15: Air freight volume Ørsta-Volda airport Hovden 2004-2011 (Avinor 2012).

Widerøe is solely operating air transportation services at Ørsta-Volda airport Hovden. It operates scheduled services to Bergen, Oslo and Sogndal. These routes are operated with Bombardier Dash Q8-series twin engine turboprop aircrafts. The routes Ørsta-Volda-Bergen and Ørsta-Volda-Oslo are operated as Public Service Obligation (European Commission Mobility & Transport 2011). Public Service Obligations are imposed by the Norwegian Ministry of Transport and Communication on thin routes to peripheral or developing regions which are vital for the social and economic development of the region which the airport serves. Public Service Obligations 'ensure on that route the minimum provision of scheduled air services satisfying fixed standards of continuity, regularity, pricing or minimum capacity, which air carriers would not assume if they were solely considering their commercial interest' (European Commission Mobility & Transport 2008). Due to the low amount of air freight handled (34 tonnes), the author has chosen to not further include the airport of Ørsta-Volda in this research. The airport has been

included and described in the research to provide a complete overview of the air freight infrastructure and network in Møre og Romsdal.

4.3.5 Freight agencies

All products and parts which are transported via air transportation in Norway have to be checked to make sure that the cargo doesn't contain prohibited items such as flammable or explosive substances. Those security checks shall be conducted by certified safety inspectors on behalf of the carrier or on behalf of the approved freight agencies. Freight which has been checked for safety has to be stored in secured warehouses before it's loaded onto an aircraft. Regulated agents and carriers might authorize there customers as registered senders, but these customers can only ship their freight with a cargo aircraft. When the freight is shipped by a passenger aircraft, the manufacturer of air freight must be approved by the CAA. A list of regulated agents and known consignors in Møre og Romsdal is displayed in table 4-16 (Luftfartstilsynet 2011).

Freight agencies	***Location***	***ID-number***
Bring Cargo AS	Ålesund	NO/RA/00022-05/1212
Bring Express Norge AS	Ålesund	NO/RA/00006-07/1213
DHL Express AS	Ålesund	NO/RA/00008-02/1212
Keuhne+Nagel AS	Ålesund	NO/RA/00019-02/1212
Panalpina Grieg AS	Ålesund	NO/RA/00014-05/1212
SAS Cargo Norway AS	Kristiansund	NO/RA/00025-06/0113
DHL Express AS	Molde	NO/RA/00008-07/0113
Posten Norge	Molde	NO/RA/00038-04/0616
SAS Cargo Norway AS	Molde	NO/RA/00025-05/0113
Widerøe Flyveselskap AS	Ørsta	NO/RA/00039-28/0516

Table 4-16: Regulated agents and known consignors Møre og Romsdal; updated 2 December 2011 (Luftfartstilsynet 2011) (EF) 300/2008.

4.3.6 Network

As shortly discussed in the previous paragraph an extensive network of direct flights is operated from the four airports located in Møre og Romsdal. Figure 4-8 visually shows the operated network consisting of scheduled inbound and outbound direct links from the four airports in Møre og Romsdal as in May 2012. The displayed network only includes direct scheduled flights operated by the airliners Norwegian, Scandinavian Airlines, Widerøe

Flyselskap, and Helitrans. Charter and non-scheduled flights have been excluded from the overview because it is unlikely that air freight is booked on these mostly summer destinations routes.

Table 4-17 shows the number of daily departures from the four airports of direct routes as in May 2012. The number of departures might slightly vary per day of the week where the average has been displayed in the table. Direct flights to the main cargo hub airport Gardermoen in Oslo are mainly clustered in the morning and evening to serve demand for (business) passenger. The direct flight from Ålesund airport to London Gatwick is only operated once a week.

Airport	***OSL***	***BGO***	***TRD***	***KRS***	***CPH***	***SVG***	***SOG***	***LGW***	***KSU***	***MOL***
KSU	4	4	2	1	-	1	-	-	-	1
MOL	6	3	2	-	-	-	-	-	1	-
HOV	6	-	-	-	-	-	2	-	-	-
AES	9	3	2	-	1	-	-	1	-	-

Table 4-17: Average number of departures as in May 2012 (Avinor 2011).

As indicated earlier the main air freight hub for Norway is Oslo airport Gardermoen. The air freight logistics area at Gardermoen airport covers 20,6 hectare of which 20.840 sqm is covered by the Scandinavian Airliners freight terminal. Hereby the airport infrastructure provides two runways of respectively 2.950 and 3.600 meters enabling the largest freighter aircraft, the Boeing 747-F, to operate with maximum payload to and from Gardermoen airport. In addition terminals with cool and freeze facilities and terminals for the building and breaking of freight containers and pallets are part of the airport infrastructure (Oslo Lufthavn AS 2012).

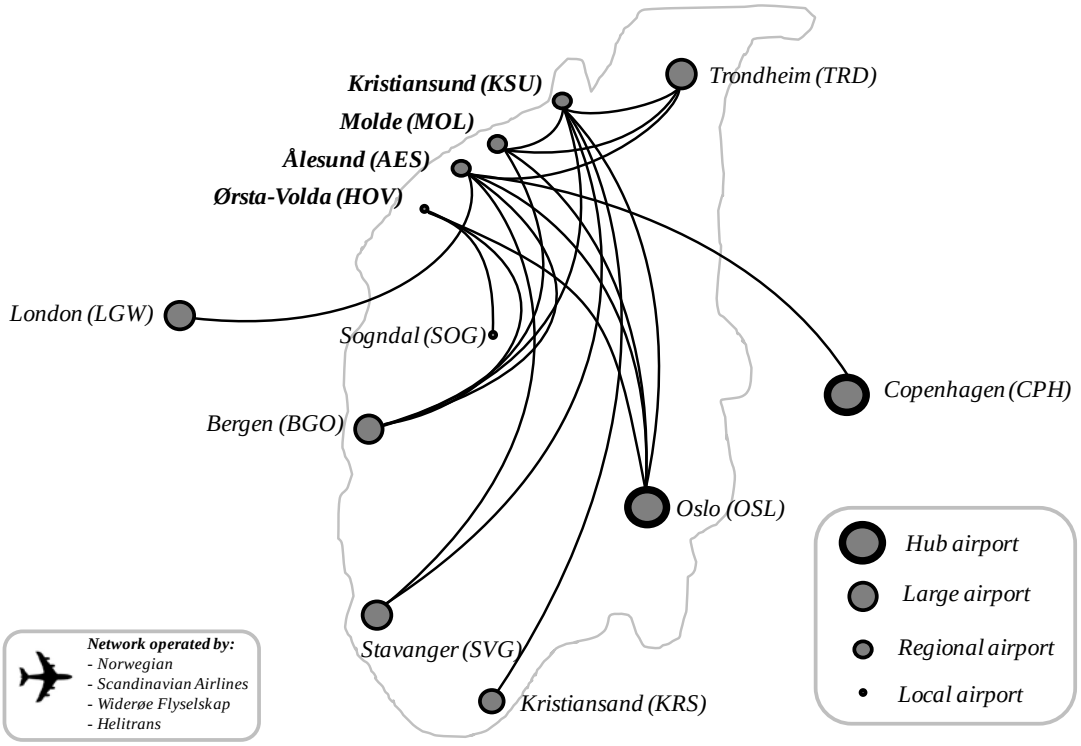

Figure 4-8: Network direct scheduled services to and from airports in Møre og Romsdal (compiled by author based on (Avinor 2011).

In addition a broad range of air freight related companies are located at Gardermoen airport including express cargo provides (DHL, Jetpack, TNT, FedEx and UPS), airlines and agents (amongst others KLM Cargo, Korean Air Cargo, and Lufthansa Cargo), freight forwarders, and distributors (Oslo Lufthavn AS 2012).

5. Regulatory framework of the air freight industry

Chapter five will provide an overview of both the international and national regulatory framework which influences the structure of the air freight industry to a large extend as it is nowadays.

5.1 International regulations

Unlike other modes of transportation such as for example sea transportation, international air transportation is regulated by a web of bilateral agreements (Morell 2011). In order to understand the structure of the air freight industry and how air freight can be used in a firm's supply chain management strategy, it is important to have a deep understanding of those bilateral agreements.

5.1.1 Air service agreements

The international air transport industry (including passengers, cargo and mail) is heavily influenced by bilateral and multilateral regulations. Air freight services, as part of the air transport industry are governed by bilateral air service agreements (ASAs), which have been established at the Chicago Conference in 1944. These ASAs "are based on the principle of reciprocity, that is, an equal and fair exchange of rights between countries with different market size, different geographical location and different economic interests, and with airlines of different strength" (Zhang and Zhang 2002, p. 277). Bilateral ASAs are negotiated between two countries and typically specify "the traffic rights of airlines, the tariffs and the number of frequency of flights" (Grosso and Shepherd 2010, p. 3). Bilateral air service agreements are not specific developed for the air freight industry. Freighter services are therefore highly dependent on ASA's which are agreed upon for the passenger industry. As stated by Zhang and Zhang (2002, p. 284) "those carriers basing their air cargo businesses on the use of belly space in passenger aircraft will rely for growth mainly upon the bilateral negotiation of air traffic rights for passenger aircraft".

5.1.2 Freedoms of the air

Nine '*freedoms of the air*' have been established "in order to provide a standardised basis for negotiating of bilateral air service agreements" (IATA 2009, p. 30). The first five freedoms of the air have been established at the Chicago Conference in 1944, four have been established later on. The nine freedoms of the air include (IATA 2009):

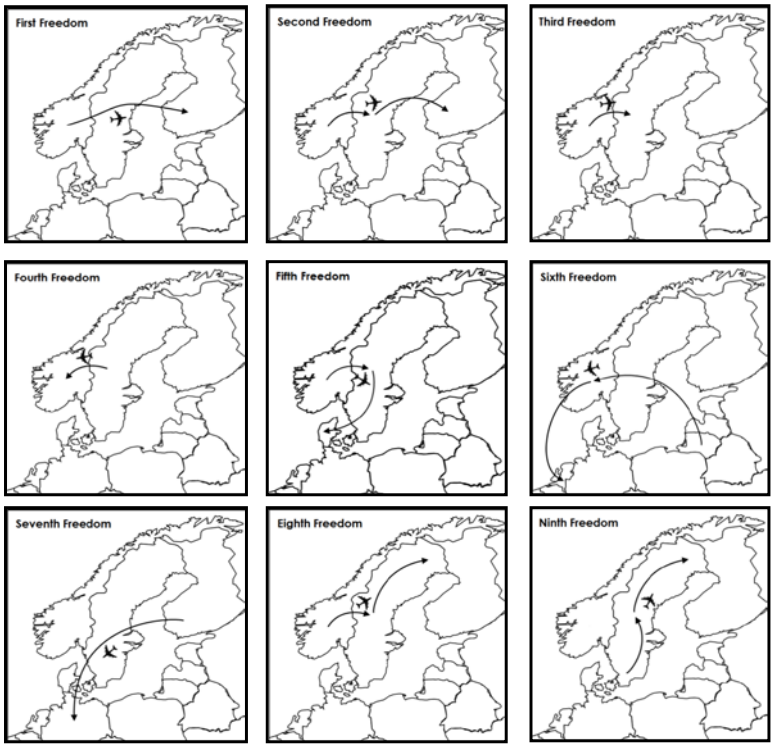

Figure 5-1: Freedom of the skies (composed by author based on (IATA 2009, p. 30)

- *First freedom*: the right to fly and carry traffic over the territory of another country without landing;
- *Second freedom*: the right to land in another country for technical reasons such as refuelling or maintenance without boarding or deplaning passengers or cargo;
- *Third freedom*: the right of an air carrier from a country to carry passengers or cargo from that country to another country;
- *Fourth freedom*: the right of an airline from one country to land in a different country and board passengers or cargo travelling to the airline's own country;
- *Fifth freedom*: the right of the airline from one country to land in a second country, to then pick up passengers or cargo and fly on to a third country where the passengers or cargo deplane;
- *Sixth freedom*: the right to carry traffic from one country through the home country to a third country;

- *Seventh freedom*: the right to carry traffic from one country to another state without going through the home country;
- *Eighth freedom*: the right to carry traffic between points within a foreign country as an extension of a service starting or ending in the airline's home country;
- *Ninth freedom*: the right to carry traffic between two points within a foreign country with no requirement to start or end the service in the airlines own country. *(Definitions are cited from (IATA 2009, p. 30).*

The first two freedoms are concerned with the transit of goods whilst the other five freedoms of the skies are dealing with traffic rights. The eighth and ninth freedoms are also known as '*cabotage*'. Cabotage refers to the transport of goods or passengers between two points in a country performed by a carrier from another country.

Due to the bilateral air service agreements "the development of international air service has been as much a function of government policy as it has been a function of commercial considerations" (IATA 2009, p. i). The large influence of government policies in the form of ASAs has restricted the 'ability for a carrier to operate services to destinations where there is a perceived business opportunity" (Zhang and Zhang 2002, p. 278). This is also recognised by Grosso and Shepherd (2010, p. 3) stating that "these restrictions prevent free route development and network optimisation, constraining flexibility in the provision of air cargo services, which is increasing necessary for modern manufacturing". As a result, in recent years the bilateral framework have been under increasing pressure to keep pace with the fast growing global economy and trade.

5.1.3 Open skies

In order to facilitate the fast growing global economy, the international air transport industry has become more liberal and deregulated in recent decades. "Freer trade in any activity, including air transportation, allows customers more choice and ensures that the most efficient producers deliver goods and services" (Button and Taylor 2000, p. 212). This trend has been supported by governments who recognized the potential benefits of an less regulated market (IATA 2009, p. ii). A major step towards a more deregulated air industry has been the development of 'open skies' agreements which were initiated by the U.S. in 1992. Open skies agreements are bilateral agreements between the US and other

countries “where carriers of the two nations can operate any route between the two countries without significant restrictions on capacity, frequency or price, and have the right to operate fifth and sixth freedom services” (IATA 2009, p. ii). The first open skies agreement have been signed between the U.S. and the Netherlands in September 1992 (Zhang and Zhang 2002).

In reaction to the open skies bilateral agreements initiated by the U.S., the European Union developed the European Common Aviation Area (ECAA) in 1996. The ECAA “allowed any EU carrier to operate in any routes in the EU (including domestic routes of any other Member State), granted them operational flexibility” (Grosso and Shepherd 2010, p. 4). This multilateral agreement was originally signed between ten candidate countries and Iceland and Norway, but increased to 35 countries nowadays, of which a large number are Balkan countries. The main aims of the ECAA are (European Commission Mobility & Transport 2008):

- Full market opening in terms of access, capacity and fares and freedom of establishment without nationally clauses (on a reciprocal basis);
- Alignment with Community legislation on issues such as safety; security and air traffic management (ATM).

The open skies and the ECAA agreements resulted in a more liberalized air transport industry, and impacted the air freight industry. In the U.S. air transport market new routes where developed, new freight carriers entered the market including related freight forwarders and integrated express carriers where introduced (Grosso and Shepherd 2010). However the direct impacts on the E.U. air freight industry have been less significant since “air cargo in the internal market plays a limited role compared to other transport modes such as rail and road” (Grosso and Shepherd 2010, p. 4).

The international air freight industry is one of the heaviest regulated industries worldwide. The industry is dominated by two main bodies, the International Air Transport Association (IATA) and the International Civil Aviation Organization (ICAO). Thereby, “nations often wish to protect their own commercial air fleet for reasons of national security but the motivation has also frequently been one of economic protectionism” (Button and Taylor

2000, p. 209). Even though the latter has been decreasing with the development of multilateral free markets between states.

The supply of air freight services is to a large extend influenced by governments. “The government affects air transportation system development through changes in the regulatory framework, infrastructure investment, airline ownership, and operational incentives” (Ishutkina and Hansman 2008, p. 6). The quality of infrastructure can be influenced by e.g. airport investment, the upgrading of air navigation equipment and the incentives to enable airports to be complaint regarding international safety and environmental standards. Besides these infrastructural influences governments might also influence operational characteristics such as price by for example tax incentives (Ishutkina and Hansman 2008).

Local governments affect the competitive environment wherein airlines and airports are operating. Local governments are using several regulatory mechanisms such as government supported state airliners (also referred as flag carriers), the liberalization of direct international routes from and to the airport and the deregulation of domestic routes. These governmental mechanisms influence the willingness of airlines to operate from a specific airport or region (Ishutkina and Hansman 2008). Thereby “the state’s influence on air cargo services and, through those services, its influence on the structure of global production networks is manifold. States regulate airline competition to varying degrees (thereby affecting the quality, quantity, and costs of services provided), play an important role (though diminishing) in infrastructure provision, and implement labour policies that affect the cost of air cargo services” (Leinbach and Bowen 2004, p. 306).

5.1.4 Multilateral bodies

As mentioned before, the international aviation industry is one of the most regulated industries. On a bilateral level, two of the main regulatory bodies are IATA and ICAO which will be discussed below.

- IATA - International Air Transport Association

IATA is the trade body for the international airline industry and was founded in April 1945. It represents some 240 airlines with origins in 118 countries which are covering

approximately 84 percent of the total international air traffic. In terms of air freight, IATA members transported 44 million tonnes of freight in 2010 of which 30 million tonnes where international (IATA 2012). “Continual efforts through IATA ensure that people, freight and mail can move around the vast global airline network as easily as if they were on a single airline in a single country - and that Member’s aircraft can operate safely, securely, efficiently and economically - under clearly defined and understood rules” (Efstathiou and Anderson 2000, p. 22). In relation to air freight, IATA serves as an intermediary between airlines and cargo agents with the main vision to create a safe, secure, reliable, efficient and profitable air cargo supply chain. This is done by incentives such as Cargo 2000 and e-Freight which are aiming for respectively a new quality management system and the reduction of paperwork throughout the entire air freight supply chain (IATA 2012).

- ICAO - International Civil Aviation Organisation

ICAO is a specialized agent of the United Nations and was founded in 1944. ICAO serves the role as a forum between their 191 member states. The main aim of the organization is “to promote the safe and orderly development of international civil aviation throughout the world” (ICAO 2012). In order to achieve their aim ICAO sets standards and regulations concerning aviation safety, security, efficiency and regularity. More recent also aviation environmental protection and sustainable development is a concern of ICAO. Concerning air freight ICAO is mainly concerned about the air freight supply chain security including the screening and inspection of cargo from unknown shippers and cargo risks categories.

5.2 National regulations

On a national level the Norwegian air industry has three important organizations regarding the aviation regulations; the Ministry of Transport & Communications, the Civil Aviation Authority, and Avinor.

5.2.1 Ministry of Transport & Communications

The aviation industry is an international industry which is to a large extend governed by international rules and agreements. The Ministry of Transport and Communications (Samferdselsdepartementet) is the responsible body for the regulatory framework for

aviation in Norway. Established on February 22nd, 1946 the ministry is "overall responsible for the framework conditions for postal and telecommunications activities, for the civil aviation, public roads and rail transport sector, and for ferry services forming part of the national road system" (Regjeringen 2011). The responsibilities of the ministry include long-range planning, research and analysis, regulatory development and budgetary matters in the abovementioned sectors. The ministry consist of five departments, where the Department of Civil Aviation, Postal Services and Telecommunications is the most relevant department regarding air freight services. Concerning the civil aviation industry, this department manages the Civil Aviation Authority (Luftfartstilsynet) and it manages the government owner interests in Avinor AS. Furthermore it's a task of the ministry to ensure good flight services on non-profitable routes by rewarding licenses to approved airliners after bidding on operating those routes. Safety and efficiency of the Norwegian aviation industry is also a main concern of the ministry (Regjeringen 2011).

5.2.2 Civil Aviation Authority

The Civil Aviation Authority (CAA, Luftfartstilsynet) is responsible for developing, introducing and adapting national and international aviation regulations in Norway. The CAA oversees the actors in the Norwegian aviation industry and control if they operate according to the laws, rules and regulations set by the CAA. Among the actors which are supervised are airlines, maintenance organizations, aircrafts, airports and certificate holders. Thereby, the CAA issues the awarding of certificates to persons and operators in the aviation industry such as airlines, pilots, and cabin staff (Luftfartstilsynet 2011).

Together with the Norwegian Ministry of Transport and Communications the CAA participates in international organizations to maintain Norwegian interests. Two of those organizations are the European Aviation Safety Agency (EASA) and the International Civil Aviation Organisation (ICAO).

5.2.3 Avinor

Avinor AS is the airport operator of 46 Norwegian airports and is responsible for the planning, development and operation of the Norwegian airport network including the provision of air navigation services (ANSP). Avinor is fully-owned by the Norwegian state represented by the Ministry of Transport and Communications (Samferdselsdepartementet,

see paragraph 5.2.1) and established on January 1st, 2003 based on the former Luftfartsverket (Avinor 2011). The main goal of Avinor is to "facilitate safe, environmentally friendly and efficient aviation in all parts of the country" (Avinor 2011, p. 4). Hereby one of Avinor tasks is to "contribute to strengthening Norway's competitiveness, and business development which requires a good transport infrastructure" (Avinor 2011, p. 13).

5.3 Economic development

Besides international and national regulations the air freight industry is also influenced by the level of economic development. It can be said that there is a clear interaction function between economic activity and air freight transportation. The facilitator effect of air transportation on economic growth is discussed by Yuan, Low, and Tang (2010, p. 215) arguing that better connections to the international air freight network will increase the growth of local and national economies. Due to better access to markets, links between businesses will be established, which results in the attraction of foreign investment in capital and resources. Hereby Capineri and Leinbach (2006, p. 23) recognizing not only the impact of air transportation on economic development but also economic competition between regions by stating that "the development of transport services and adequate infrastructures to handle freight flows have become an important factor of economic competition between regions".

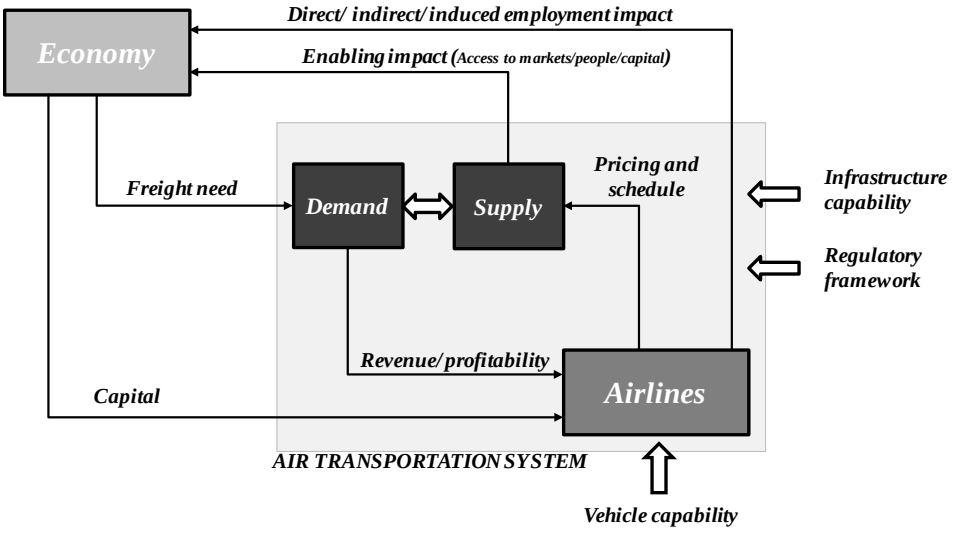

Figure 5-2: Feedback based interaction between the air transportation system and an economy (Ishutkina and Hansman 2008).

The interaction between air transport and an economy is visually described in figure 5-2. In this overview the output of the transportation system is dependent on the vehicle capability, airline capacity, regulatory framework and infrastructure capability. Further the figure shows the demand and supply relationship where supply is provided based on the pricing and schedule set by the airline based on the revenue it is providing on a particular route. The air transportation system is impacting the economy by providing employment and enabling effects. On the other hand the economy provides capital and air freight demand into the air transportation system (Ishutkina and Hansman 2008). The impact of economic influences on air transportation is recognized by Yuan, Low, and Tang (2010, p. 219) stating that “the air transport and logistics industry cannot operate in isolation from economic and environmental influences”.

The link between growth in the air freight industry and GDP has been notified earlier in this thesis. The growth rate of the international air freight industry has varied in the past between 1,8 and 2,5 times the economic growth rate (Cech 2004). Changes in the economic climate are impacting air freight traffic. Especially all-cargo operations are volatile for changes in the economic climate. This can be explained by the fact that “combi traffic involves more traditional carriers and is related to passenger traffic” (Kupfer et al. 2009, p. 7). In times of economic recession, all-cargo operations will be easier reduced than combined cargo operations in the belly hold of passenger aircrafts.

6. The air freight supply chain

Chapter six will provide a description of the structure of the air freight supply chain. A variety of aspects will be discussed. Amongst others the goods and information flow, supply chain actors, the supply and demand side and the costs of the air freight supply chain will be discussed.

6.1 Air freight supply chain process

The process of transporting goods via air freight services is a complex process which involves a variety of supply chain actors. It requires “on-going coordination between them, both with respect to the physical movement of products and the management and exchange of information” (Grosso and Shepherd 2010, p. 9). The complexity of the system is best described by Power (2005, p. 255) stating that “global shipments are estimated to require on average the involvement of 27 separate parties to complete. These include brokers for buying cargo space, carriers for inland transport, compliance intermediaries at both country and regional levels and government agents covering tax and other compliance issues”. The air freight supply chain can be divided into three core processes; physical carriage of freight, freight forwarding, and integration.

Appendix C shows a schematic overview of the physical flow as well as the information flow of the air freight supply chain. According to (Morell 2011, p. 155) “air cargo is mostly used for the export of goods to another country since mostly domestic or internal movements will go by surface transport”. Therefore the air freight supply chain depicted in appendix C represents a direct international shipment with the use of a cargo agent. Other forms of air freight supply chains include indirect shipments, domestic shipments, and transit shipments. The main differences between the different types of air freight supply chains are the involvement of customs clearance, import- and export duties, and the required documents.

This paragraph will continue by describing the different air freight supply chain actors, documents and the physical- and information flows in relation to the depicted air freight supply chain in appendix C.

6.1.1 Air freight supply chain actors

The air freight supply chain is initiated by the *consignor* with a request for the transportation of a consignment (shipment) via air freight services. The consignor should not be mistaken with the shipper. The shipper is the person or firm "whose name appears on the air waybill or in the shipment record as the party contracting with the airline(s) for carriage of goods" (IATA 2009, p. 4). In case a firm is booking their air freight services directly by the airlines, the firm will be the shipper (which is not common). In case the firm is booking their air freight services through a *cargo agent*, the cargo agent will carry the name of shipper and have the contact with the airlines.

The *freight forwarder* is the party who arrange the physical carriage of the goods on behalf of the shipper or consignee as indicated by Morell (2011, p. 109) "a freight forwarder is an intermediary who acts on behalf of importers, exporters or other companies or persons involved in shipping goods, organising the safe, efficient and cost-effective transportation of goods". The carriage of the goods includes the transportation from the shipper's warehouse to the origin airport, the collection of the goods at the destination airport and the final transportation (possibly outsourced) to the consignee. Thereby the freight forwarder is responsible for preparing the necessary paperwork involved with the shipment. In many cases the freight forwarder act as an intermediary between the airliners and shippers (Grosso and Shepherd 2010). "Forwarders vary in size and type, from those operating on a national and international basis to smaller, more specialized firms, who deal with particular types of goods or operate within particular geographical areas" (Morell 2011, p. 110).

The importance of freight forwarders in the air freight industry is recognized by Yuan, Low, and Tang (2010, p. 218) stating that "freight forwarders in the logistics industry play a central role in the airfreight transportation as middleman for managing information flow and coordinating the movements of physical goods among airlines, air-cargo terminals and customers".

The freight forwarder is the most important customer of freighter airlines, and is often directly located at main hub airports. The presence of freight forwarders at airports has a large influence on the choice of freighter airlines to operate from a certain airport since

"the presence of an sizable airfreight industry is a pull factor and driver for freighter operators and air cargo traffic at the airport" (Yuan, Low, and Tang 2010, p. 218).

The *carrier* is the actor who provides the air transport services from the origin airport to the destination airport. There are various types of carriers such as combination carriers, all cargo carriers, integrators, and contract freighter operators. The function and role of the different type of carriers in the air freight supply chain have been discussed in detail in paragraph 4.1.5.

The *ground handler* is "an agent at an airport that physically handles the freight; this usually refers to whenever freight is loaded, unloaded, transferred, stored, retrieved, broken down or consolidated" (Petersen 2007, p. 13). "The ground handling at airports is carried either by an airline's own staff or by third party service providers. The IATA standard ground handling agreement defines the menu of services that can be offered including general cargo and mail handling, document handling, customs control, the handling of irregularities and ramp services" (Morell 2011, p. 167). The use of third party service providers is economically more beneficial when the freight volume at a certain airport is not large enough for an airline to invest in expensive equipment and skilled labour for that specific airport. The use of third party services has been increased due to the adaption of EU Directive 69/67/EC in October 1996 which "forced EU airports which handled more than two million passengers or 50,000 tonnes of air cargo a year to open up their ground handling to third party suppliers" (Morell 2011, p. 167). As a result of the opening up of the ground handling services by the Directive, contract prices have been reduced and service quality increased.

Customs are "a government authority designated to regulate the flow of goods to and from a country referred to as imports into the country and exports from the country" (Morell 2011, p. 312). The three main functions of import and export customs are trade facilitation, revenue rising, and customs control of which the latter is the most relevant in the air freight supply chain. The importance of revenue rising for customs has declined strongly since tariff barriers have gone down. An exception are developing countries where the main function of customs is still revenue funding (Zhang and Zhang 2002, p. 284). Customs control might include issues like prevention of infiltration of hazardous goods,

the protection of intellectual property rights and tariff collection. The role and function of customs in the air freight supply chain will be discussed in more detail in paragraph 6.6.

Airports form an important part of the infrastructure supporting the air freight supply chain. The capacity of airports is often defined in airside and landside capacity, where airside capacity is referring to the number of runways and landslide capacity to the size of terminal area (Yuan, Low, and Tang 2010).

6.1.2 Air freight supply chain documents

The most important document used in the air freight supply chain is the air waybill. The air waybill is "a document made out by or on behalf of the shipper, which evidences the contract between the shipper and airline(s)" (IATA 2009, p. 3). When an individual consignment is shipped by a forwarder via air freight services, a House Air Waybill (HAWB) is used. In the case where a number of consignments from different shippers are consolidated by a forwarder into a larger shipment, a Master Air Waybill (MAWB) is used. Besides the MAWB, all the single consignments in the larger shipment will have their own HAWB. Information on the air waybill includes shipper and consignee information, the airports of origin and destination, a description of the goods including the quantity, weight and measures and has to be signed by either the shipping agent or actual carrier (Morell 2011).

Other used documents in the air freight supply chain are the certificate of origin, invoice, packing list, goods declaration, and the flight manifest. The certificate of origin states in which country the goods in a particular export shipment have been manufactured and has to be certified by an authorized body. The invoice is a document which is required by the customs authority of the importing country and states the value (i.e. selling price) of the imported goods, transportation costs, insurance, and the used terms of delivery and payment. The invoice is required by the customs authority in order to determine the customs value of the imported goods. The packing list states the content of the consignment and how the single items are distributed in individual packages (IATA 2009). The goods declaration form is "a statement made in the form prescribed by customs, by which the persons interested indicate the custom procedure to be applied to the goods and furnish the particulars which then customs require to be declared for the application of that

procedure" (Morell 2011, p. 314). Finally the flight manifest contains the details of the consignments which are loaded onto the aircraft (IATA 2009).

The above defined air freight supply chain is highly dependent on other supporting activities which enables goods to be transported door-to-door from the shipper to the end customer. "The integration of the airfreight sector with other supporting sectors in the logistics industry is necessary for a competitive air cargo supply chain that may involve more than one mode of transport to facilitate a seamless flow of cargo from its origin to destination" (Yuan, Low, and Tang 2010).

Another way of visualizing the air freight supply chain can be seen in figure 6-1, which is based on the business concentration. As can be seen basically three types of air freight networks do exists. The first network represents the integrated network where all the process steps in the air freight supply chain are fulfilled by one partner, the integrator. Thereby integrators using their own assets from the point of collection to the point of delivery. This integrated network accounts approximately for 85 percent of all international air transport tonnage. The second and third networks are so called non-integrated networks and together account for 15 percent of the total transported tonnage via air freight services. The second type of network is operated by large forwarders which are using their own network and branches to ship goods from the point of collection to the point of delivery. The last type of network is operated by small and medium sized freight forwarders which are dependent on agency agreements in order to deliver the goods from the point of collection to the point of delivery (Steiger 2010).

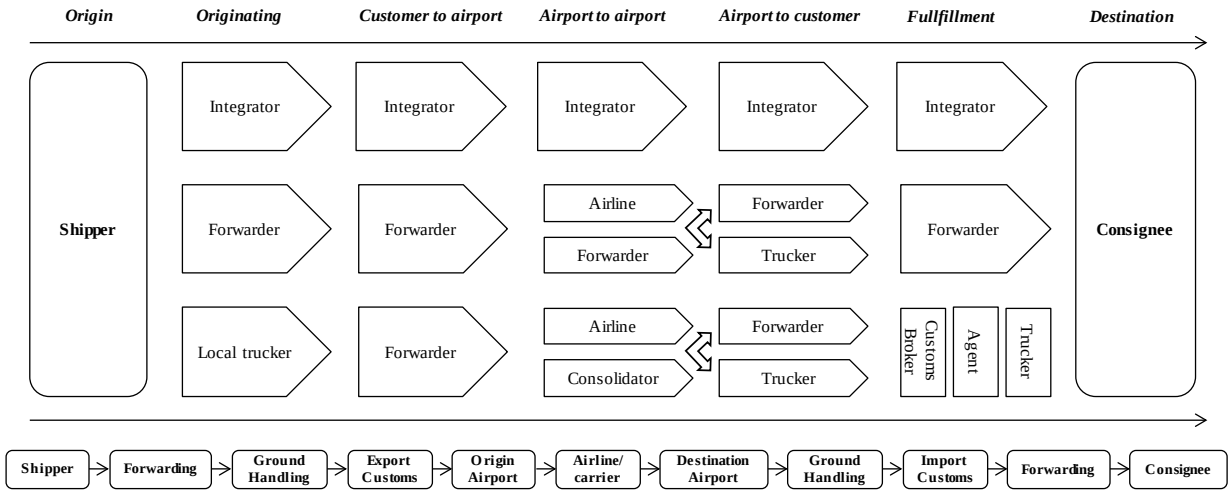

Figure 6-1: Air freight supply chain process (Steiger 2010).

6.2 Costs of air freight services

Transportation can be viewed as the key element in a logistics chain, which supports the physical movement of materials between separate activities and supply chain actors. According to Tseng, Yue, and Taylor (2005) transportation accounts for close to one third of the total logistics costs, as can be seen in table 6-1 (based on an estimation from Air Transport Association and includes transportation, corridors, containers, pallets, terminals, labours and time). Thereby the costs of logistics and distribution "account for 10% to 30% of the total production cost of an item" (Capineri and Leinbach 2006, p. 25). This shows the importance of transportation (i.e. air freight services) in a global logistics supply chain. The transportation costs are likely to vary within different types of industries and transportation modes. "For those products with small volume, low weight and high value, transportation costs simply occupies a very small part of sale and is less regarded; for those big, heavy and low-valued products, transportation occupies a very big part of sale and affects profit more, and therefore it is more regarded" (Tseng, Yue, and Taylor 2005, p. 1661). In terms of transportation modes, "for cargo, it is much more expensive to use air transportation than surface transportation (road, sea, and rail)" (Zhang and Zhang 2002, p. 275). This is recognized by Morell (2011, p. 24) stating that "given the fact that air rates are some 10-15 times those for sea transport, only higher value to weight items are likely to be able to support the cost of going by air in the final price of the product". However the relative costs of air transportation has decreased over the past decades. This is recognized by Nordås, Pinali and Grosso (2006, p. 9) stating that "the relative costs of air transport has for instance declined by 40% between 1990 and 2004".

Logistic activity	**Breakdown**
Transportation	29,4%
Inventory	17,4%
Warehousing	17,0%
Packaging	11,9%
Management	11,0%
Movement	7,8%
Ordering	5,5%

Table 6-1: Breakdown of logistics costs per item (Tseng, Yue, and Taylor 2005).

Following Hensher, Brewer, and Button (2001) air freight services are selected "when the value per unit weight of shipments is relatively high". This means that even though the high price level of air freight services; transportation costs in supply chains which use airfreight services are not always extremely high in comparison with the value of the time-sensitive items being transported (Zhang and Zhang 2002).

A more detailed analysis of the costs of air freight as a mode of transport can be done by applying the total distribution cost (TDC) framework, which is displayed in figure 6.2. The total distribution costs consists of transport related costs and inventory related costs. When the TDC framework is applied on long-distance transportation, "it is argued that the use of slower modes (such as land or sea transportation) may lead to higher total distribution costs than the air mode even though the latter may involve significantly higher freight charges" (Zhang and Zhang 2002, p. 276).

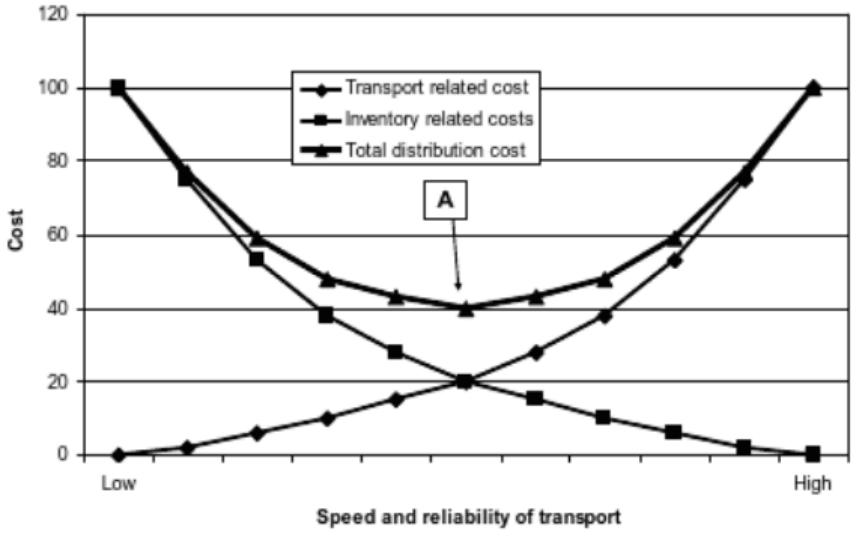

Figure 6-2: Total distribution cost model (Morell 2011, p. 179).

This can be declared by the trade-off which has to be made in the TDC framework between transportation costs and inventory costs. By selecting a low priced but slow mode of transport, sea transportation for example, the costs of transportation will be low. On the other hand, since sea transportation is a slow mode of transport, firms have to hold larger stock level because replenishment cycles will be longer, which causes high inventory costs. Thereby the in-transit stock value will be high. Thus "if inventory costs are very high relative to freight costs, air transportation becomes an attractive option" (Zhang and Zhang 2002, p. 267). This effect aggravates when the distance of the transportation

increases. In today's industry, where firms increasingly outsource their manufacturing and were firms sourcing raw-materials on a global scale, transportation distances are increasing significantly. This is recognized by Hummels (2007) who found that on average in 1975 air cargo travelled 4.184 kilometres whilst this increased to 5.444 kilometres in 2004[6].

Transportation costs are typically expressed in ad valorem terms where ad valorem means "the cost of shipping relative to the value of the goods" (Hummels 2007, p. 135) which is equivalent to "the percentage change in the delivered price as a result of paying for transportation" (Hummels 2007, p. 135). The ad valorem transportation costs are dependent on three factors namely the distance of transportation, the value to weight ratio of a product and the quality of the transportation service used. It is estimated that "a 10 percent increase in product price leads to an 8,6 percent fall in the ad-valorem transport costs." (Hummels 2007, p. 137). In other words, "transportation lowers the delivered price of high quality goods of high-quality relative to low-quality goods" (Hummels 2007, p. 137).

Hummels (2007) is mentioning that end consumers are delicate for changes in the price of goods and not for changes in the price of transportation of the good. Thereby Hummels (2007, p. 134) is stating that "if transportation is but a small fraction of the delivered price, then when choosing transport mode, the explicit costs of transportation may be trumped by implicit costs such as timeliness or reliability". In other words if transportation costs aren't a large proportion of the final price of a good, the extra costs spend on air transportation might be covered by implicit costs such as the high reliability and timeliness of air transportation.

6.3 Quality of air freight services

According to Leinbach and Bowen (2004, p. 300) "the quality and capacity of air cargo services are dependent, in part, on the policies of national states and the importance of air-eligible products within regional economies". Thereby the airline competition is regulated by states in varying degrees, which influence the quality, quantity and costs of the air freight services provided. The impact of policies, regulations, and states has been

[6] Metrics are converted from miles into kilometer by the author

discussed in chapter 5. “Improvements in the quality of transportation services – like greater speed and reliability – allow corresponding reorganizations of global networks of production and new ways of coping with uncertainty in foreign markets” (Hummels 2007, p. 132). Quality increase in any part of the air freight supply chain will therefore most likely positively influence the competitive strength of the supply chains its serving. Another factor influencing the quality and capacity of air freight services which is closely related to regulations is the impact of noise pollution.

Noise pollution is a major concern for air freight operations, which is recognized by Gardiner, Ison, and Humphreys (2005, p. 394) stating that “environmental restrictions such as noise limits and night curfews are the most common barriers for freighter operators”. Noise pollution is especially an issue for freighter operators because freight tends to be transported overnight when many airports apply ‘*night flying restrictions*’ to reduce noise pollution. In addition commonly older converted passenger aircrafts are used to transport freight which produces more noise than more recent developed freighter aircraft. This impacts the network of freighter operators and causes that their network is restricted to airports without such noise pollution restrictions instead of a network that is most favourable for the characteristics of freight movement (Gardiner, Ison, and Humphreys 2005). Furthermore airport congestion and slot scarcity is seen as a restrictor for air freight carried in the belly hold of passenger aircrafts, since passenger aircrafts operating at peak hours. Airport congestion is of less importance of all-cargo carriers which as mentioned tends to operate at night.

6.4 Motives for using air freight services

Following Nordang and Grimsbo (2000, p. 23) the demand for air freight services derives primarily from goods with high demand level, goods which need to be transported in a short notice and goods with high quality requirements in terms of transportation. Their survey, conducted in Norway over 68 respondents, showed that 57 percent of the firms indicated that time is the most important reason to make use of air freight services, followed by reliability (16%), price (13%), and frequency (13%). Thereby they mention that the results are fairly consistent for all industries, except the fishery industry where time is selected by 83 percent of the firms. The combination of price and quality combined

with the price per mileage results in basically no alternative transport solution for this commodity.

Park, Choi and Zhang (2009) have conducted a survey over 245 air cargo express service users to identify the users expectation of air cargo express services based on 26 services attributes. The survey has been conducted on three target groups; forwarding companies, domestic shipping companies and foreign shipping companies active on the Korean market. The authors identified those three target groups as the '*user*' of air express services since "initially the sales agent of airlines, freight forwarders, have evolved to become third-party brokers/operators who make contract with shippers and may further coordinate and manage the cargo shipment" (Park, Choi, and Zhang 2009, p. 326). The survey showed that the service attribute economic efficiency ranked highest; meaning that the pricing of air express services is the most important service indicator for air express service users. Second most important service attribute according the survey is accuracy followed by dependability, promptness, convenience and safety. An overview of the complete survey results is added in appendix D.

Yuan, Low, and Tang (2010, p. 218) provide a more controversial look on the attractiveness of air freight services by stating that "under one bill of loading for a door-to-door delivery, the attractiveness of air cargo services offered in the airfreight sector depends not on the basis of its performances, reputations or cost of services, but on the availability of greater inter-modal coordination which will result in a lower total cost". Quality improvements in air freight services might neglect when other connecting modes of transportation can't keep pace with the quality improvements.

6.5 Customer satisfaction

An important trend in modern businesses has been the outsourcing of non-core activities. "Outsourcing is an increasingly important issue pursued by companies seeking improved efficiency and effectiveness of a company's logistics functions" (Meng et al. 2010). Client satisfaction hereby is an important indicator in the success of the relationship and to indicate possible bottlenecks which could be transformed into improvements. A survey conducted by Meng et al. (2010) investigates factors that influence the level of satisfaction

of firms that are outsourcing their air cargo logistics to air cargo logistics providers. The survey, conducted over 384 companies and with a response rate of 42,1 percent, reveals that four service attributes of air cargo logistics providers explain 74,8 percent of the client satisfaction level. Those service attributes are reliability (46.1%), agility (12,5%), customization (9,9%), and flexibility (6,3%).

6.6 Bottlenecks in the air freight supply chain

As such in most transportation modes the output of the conventional air freight supply chain is influenced by bottlenecks. Before discussing the occurrence of bottlenecks it should be noted that integrators and 4PL providers should not be included in the discussion towards bottlenecks. As indicated by Efstathiou and Anderson (2000) “integrators maintain their own seamless operations and the 4PL’s perform no activities other than assigning cargo to the appropriate carrier”.

Nordang and Grimsbo (2000) are not specifically focussing on bottlenecks in the air freight supply chain, but their survey shows a significant potential for improvements. They interviewed 40 companies about their level of satisfaction of the air freight transport chain based on the booking process, pick-up and delivery, terminal process, air transport process, and custom clearance process. It shows that firms are most satisfied with the customer clearance process and the booking process; with respectively a score of 4,1 and 4,0 on a 1 (poor) to 5 (good) scale. Processes with a low level of satisfaction are the terminal process and air transport process with respectively scores of 3,3 and 3,6.

Whilst Nordang and Grimsbo (2000) are indicating that companies are highly satisfied with the customs clearance process; Kasarda and Green (2005) statistically prove that the customs clearance process is a major bottleneck in air freight services. “Even though customs’ primary purpose is to enforce trade policy, intercept contraband, and levy duties and taxes, constraints such as subjective and nontransparent valuation, prolonged delays, as well as internal Customs Bureau inefficiencies serve as serious barriers to fast-cycle logistics and country attractiveness for foreign manufacturing investment”. The customs clearance procedures is “a key constraint on development of freer and more efficient international trade” (Zhang and Zhang 2002, p. 284) and heavily increases the turnaround time of trans-shipments. The time delays due to customs activities are mainly caused by

the clearance time and by the predictability and transparency of the customs process. “Unpredictable-, time consuming and unexplained changes in customs processes are likely to disrupt logistical flows” (Zhang and Zhang 2002, p. 284). Following Grosso and Shepherd (2010) time spent in the customs process in China approximately accounts for 40 per cent of the total international transportation lead-time, whereas according to (Morell 2011, p. 159) “customs clearance procedures accounts for as much as 20 percent of average transport time and 25 percent of average transport costs of imports” of OECD member states. Table 6-2 shows the customs clearance time for import air and marine shipments into Korea and Japan in 2002. Even though customs clearance times for air transportation are relatively shorter than for marine transportation, custom clearance time in Korea and Japan still accounts for respectively 2.7 and 1.1 days of ‘*delay*’.

	Arrival -> Entry	***Entry -> Declaration***	***Declaration -> Acceptance***	***Total***
Air Transport				
Korea	5.9 hours	2.4 days	2.2 hours	2.7 days
Japan	3.5 hours	21.6 hours	0.6 hours	1.1 days
Marine Transport				
Korea	1.8 days	7.4 days	3.3 hours	9.4 days
Japan	35.1 hours	46.0 hours	5.6 hours	3.6 days

Table 6-2: Import customs clearance time air and marine transport Korea and Japan 2002 (Kim 2003).

Customs clearance is a transaction-based processing philosophy. With the emerging of logistical management systems and in particular the JIT production philosophy, the volume of individual shipments has been decreasing whilst the value of individual shipments has been increased. This stresses the customs clearance processes since these are transaction-based and possible increasing time delays even more.

Inter-company relations might be another source of bottlenecks in the air freight supply chain. An example of inter-company inefficiencies is outlined by Neiberger (2008) stating that customers and freight forwarders have been highly dissatisfied with the time between the landing of an airplane and the release of the goods to the freight forwarder. Due to the large number of supply chain parties involved (worst case scenario the airline, ground handler and freight forwarder) valuable time is lost in this part of the air freight supply

chain. Nowadays both air freight forwarders and airlines seek to gain more control over the customer's value chain by the integration of functions in the air freight supply chain. Large freight forwarders are integrating ground services into their provided services. Therefore they now "receive goods directly from the aircraft ground handling services and unpack them and bring them through customs themselves, or supervise this directly" (Neiberger 2008, p. 252). This bottleneck is the perfect indicator of the success of integrators, who are not influenced with such inter-company inefficiencies.

7. Multiple case study analysis

In chapter seven the multiple case study findings will be discussed. This will include an overview of the data gathering process, an overview of the firm sample characteristics and finally the results obtained from the multiple case study interviews.

7.1 Data gathering

Due to the lack of available research on the incentives of firms for using air freight services in their supply chain management strategy, a multiple case study has been selected for the data gathering method. According to Yin (2003) this in-depth study method of a small number of firms is the most appropriate design for an exploratory research. To conduct the multiple case study, an interview guide has been developed in order to collect the data from the selected firms. The interview guide includes a number of categorical, ranking, and open-ended questions. In addition the interview guide includes several '*follow-up*' questions to get a deeper understanding of the given answers on the ranking questions. Besides the interviews secondary data such as annual reports have been used to get a better understanding of the structure of the interviewed firms.

The firms included in the multiple case study have been selected based on their intensity level of air freight usage. It can be assumed that the role of airfreight services within a firm which is extensively using it is more deeply understood due to experience and will lead to a more valuable input into the research. The ground handling agents of both airlines operating at the three Avinor operated airports in Møre of Romsdal; SASCargo (operating for Scandinavian Airlines) and Røros Flyservice (operating for Norwegian); were asked to provide an overview of their regular and occasional customers. From the overview provided, the regular users which are operating in the electromechanical industry have been selected as potential firms to include in the research. One might argue for the constraint concerning the role of freight forwarders. As indicated by Kristian Stokke[7] from SASCargo Kristiansund, approximately 90 percent of the air freight services are booked through a handful of freight forwarders. When using the response of the ground handlers, possible large users of air freight services, which outsourced their air freight transportation

[7] As referred to in e-mail contact at 28.03.2012

to freight forwarders, might be unwillingly excluded from the research since the freight forwarder is operating the services for their clients under their name. Due to a lack of resources in the form of time the author has chosen to include the response of the two ground handling agents.

7.2 Multiple case study sample characteristics

A total of ten firms have been contacted via telephone to arrange meetings to conduct the interview face-to-face on site. From the ten firms contacted, five firms agreed to cooperate in the research. Due to geographical distances, one firm preferred to conduct the survey via e-mail. The interviews have been conducted with managers responsible for freight or logistics within the firms, and had a duration between 45 and 90 minutes.

A decision has to be made regarding the anonymity of the case firms. According to Yin (2003, p. 157) “the most desirable option is to disclose the identities of both the case and the individuals”. Disclosure of the identities will strengthen the quality of the case analysis in two manners. First “the reader is able to recall any other previous information he or she may have learned about the same case - from previous research or other sources - in reading and interpreting the case report” (Yin 2003, p. 157). Secondly “the entire case can be reviewed more readily, so that footnotes and citations can be checked, if necessary, and appropriate criticism can be raised about the published case” (Yin 2003, p. 158).

One interviewed firm required to treat the provided information confidentially in such a way that the firm’s name remains anonymous. Even though this might negatively impact the quality of the case analysis, the analysis will be handled anonymous in terms of firm identity and respondent’s identity (personal name). The multiple case study consists of a sample size of five firms. An overview of the interviewed firms and their activities can be found in table 7-1.

Firm	*Industry*	*Products*	*Location*	*Respondent*
A	Electronics	Lightning products	Molde	Export & distribution manager
B	Maritime	Thruster systems	Molde	Shipping manager
C	Communication	Satellite communication	Ålesund	Service coordinator
D	Shipbuilding	Offshore vessels	Aukra	Yard director
E	Maritime	Lifting cranes	Molde	Transport coordinator

Table 7-1: Multiple case study interview firms.

7.3 Analysis of the multiple case study results

Several techniques in analysing case study data do exist. The most relevant analysing technique for this multiple case research is the cross-case synthesis technique. The cross-case synthesis technique considers each individual case as a separate study. The technique will "aggregate findings across a series of individual studies" (Yin 2003, p. 134).

The cross-case synthesis technique can be applied in several structures. One of the possibilities is to "create word tables that display the data from the individual cases according to some uniform framework" (Yin 2003, p. 134). Such tables can be further developed into tables which display data on a 'case-by-case' basis. These tables can be used to 'analyse whether different group of cases appear to share some similarities and deserve to be considered instances of the same type of general case" (Yin 2003, p. 135). The cross-case synthesis technique together with cross-data data tables is used to analyse the multiple study results.

Besides the analysing techniques also a format to write case study reports has to be selected. The multiple case version of the classic single case study method is selected as the most appropriate format (Yin 2003). A cross-case analysis will be presented complemented by single case in-depth examples in the form of narratives. Furthermore according to Yin (2003, p. 137) the quality of the multiple case study analysis can be improved by:

- The analysis should show that the author attended to *all the evidence;*
- The analysis should address all major *rival interpretations*;
- The analysis should address the most *significant aspect* of the case study;

- The author should use its own *prior, expert knowledge*.

The analysis will continue with first a short introduction of the interviewed case study firms. Thereafter a cross-case analysis of the multiple case study will be given. The used questionnaire for the interviews is attached in appendix E. A complete overview of the attained interview results can be found in appendix B.

7.4 Multiple case study firms

A brief introduction of the five case study firms will be provided in order to give an overview of their main business activities, financial results and air freight usages. A complete overview of the company statistics can be found in appendix B.

- ***Firm A***

Firm A is a Norwegian industrial agglomerate that develops, produces and distributes illumination products to the global market. The group consists of several subsidiary firms with production sites in Europe, USA and Canada. The group produces lightning products for two markets namely building solutions and marine and offshore solutions. Building solutions includes lightning fittings for office & commercial buildings, industrial buildings, shopping centres, and health institutions. The marine and offshore industry solutions include fittings for commercial marine, cruise ships & ferries, oil & gas, and navy & obstruction lightning. The total firm has a workforce of approximately 1.500 employees. The production facility in Molde produces solely products for the professional building solutions industry and employs approximately 400 employees. In 2010 the firm achieved an operating result of 136,9 million NOK. Approximately 10 percent of the total import volume and 5 percent of the total export volume is transported via air freight services. In terms of value, approximately 1 percent of both the total import and export value is transported via air freight services. Firm A is shipping less than 5 items per week via air freight services.

- ***Firm B***

Firm B is a privately owned designer and manufacturer of thruster systems including electric, hydraulic, and diesel drive systems established in 1912. The product range

includes tunnel thrusters, azimuth thrusters, low-noise thrusters and thruster control systems. Located in Molde, firm B is distributing its products onto a global market. In 2010 firm B achieved an operating result of 147,7 million NOK. Firm B has a workforce of 265 employees who are all located at the manufacturing site and offices in Molde. In terms of volume, 10 percent of the total import volume is transported via air freight services and 30 percent of the total export volume is transport via air freight services. Firm B is shipping between 5 and 10 items per week via air freight services.

- ***Firm C***

Firm C is an international concern which is providing maritime mobile satellite communication services for the shipping, offshore oil & gas, and fishing markets. The firm operates nine satellites and sells satellite airtime. The firm is presence in more than 40 countries with approximately 1.500 employees. One of the subsidiaries of firm C is located in Ålesund and is specialized in VSAT (internet & telephone) and TVRO (television) systems and solutions. The firm has installed more than 2.500 stabilized antennas all over the world in the maritime industry. Firm C is installing, maintaining, and supporting the antennas worldwide with a workforce of 140 employees. The company achieved an operating result of 9,4 million NOK in 2010. Firm C is shipping between 5 and 10 items per week via air freight services.

- ***Firm D***

Firm D is an international ship building firm designing and constructing highly customized offshore vessels (OSV) which are used in the offshore oil & gas exploration and production industry. Constructed vessels include platform supply vessels (PSVs), anchor handling tug supply vessels (AHTSs), seismic vessels, and LNG-fuelled vessels. Firm D has a total of nine shipbuilding facilities worldwide, of which five are located in Norway. All vessels are designed and engineered in Norway where after the hull production takes place in Romania, Brazil, or Vietnam. Dependent on the final geographical operational area of the vessel, the manufactured hulls are outfitted in the above mentioned countries or in Norway. The interview has been performed with the yard manager of one of the Norwegian shipbuilding facilities which is located in Aukra. In 2010 firm D achieved an operating result of 717,4 million NOK. The total group has a workforce of approximately 8.500 employees. The interviewed shipbuilding facility in Aukra employs 127 full time employees with in addition 100 to 300 temporary workers dependent in the workload

which is related to the number of vessel deliveries. Both in terms of value and volume firm D is exporting and importing less than 1 percent via air freight services. Firm D is shipping less than 5 items per week via air freight services.

- ***Firm E***

Firm E is part of an international organization and has expertise in the manufacturing, installation, service and maintenance of cranes, lifting equipment, and hydraulic equipment for the offshore and onshore mechanical industry. The production facility of Firm E is located in Hjelset, 15km outside the municipality of Molde and has a workforce of approximately 60 employees. The administrative office is located in the city centre of Molde. Besides the manufacturing site in Hjelset the firm is closely operating with two other manufacturing sites in Poland and Korea which are part of the international organization. On a weekly basis Firm E is shipping more than 10 items via air freight services. Both in terms of value and volume, air freight transportation accounts for 5% of the total import and 10% of the total export of the firm. In 2010 firm E achieved an operating result of 3,8 million NOK.

7.5 Cross-case analysis

After the included firms have been shortly described, a cross-case analysis will be provided. The analysis will include the relevant topics according to the developed research questions and conceptual and theoretical framework. This will be done according to the cross-case synthesis technique described in paragraph 7.3.

7.5.1 Transportation mode selection criteria

As a mode of transport, air freight has several specific attributes such as high costs, fast delivery times, high frequency, high security and high quality which distinguish it from other transportation modes such as road, rail and sea. Here cost includes the total cost involved of shipping a consignment from the consignor to the consignee and in general is higher for air freight transportation in respect to other modes of transportation. Delivery time includes the time from the collection of the consignment at the supplier until the delivery of the consignment at the focal firm or the time from collection of the

consignment at the focal firm until the delivery of the consignment at the end customer. Air freight services provide faster delivery times than the other modes of transport and this time advantage aggravates when the distance of the route increases. The high frequency of air freight services, measured in number of departures, is an advantage of air freight transportation compared to other modes of transportation. Security of the transportation mode is expressed in terms of the risk of damage and loss of goods. Air freight transportation is often labelled as most secure transportation mode. The quality of transportation services can be measured via a broad panel of indicators. Concerning air freight, quality focuses mainly on on-time delivery (Morell 2011).

The firms were asked to rank these five attributes on a scale from 1 (not important) to 7 (most important) to indicate the importance of the attributes in their choice of using air freight services instead of other modes of transportation. The case study shows that the fast delivery time is by far the most important attribute of air freight services for firms. The second most important attribute is cost followed by security, frequency and quality. These results are fairly similar to the survey performed by Nordang and Grimsbo (2000) under 68 Norwegian respondents which showed that time was the most important attribute to select air freight services followed by reliability, price and frequency.

The question has been asked both for inbound and outbound transportation. All firms indicated that there was no difference in the importance of the attributes for their inbound or outbound flow. Delivery time is for both transportation flows the most important attribute.

Attribute	*A*	*B*	*C*	*D*	*E*	*Average score*
Delivery time	7	7	7	7	7	7.0
Cost	4	4	6	1	6	4.2
Security	5	7	7	1	1	4.2
Frequency	5	7	4	1	3	4.0
Quality	7	4	4	1	1	3.4

Table 7-2: Importance of air freight attributes in mode selection.

The importance of the attribute fast delivery time of air freight services is stated by firm A as ‘raw-materials and end products are only shipped via air freight services when they are urgently needed and where the modes road, sea and rail are not able to deliver the raw-

materials or end products in time'. The attribute cost is relatively unimportant for the firms in their choice of using air freight services. Firm A is, amongst other products, transporting critical spare parts needed to repair thruster systems on vessels via air freight services. During the reparation, the vessel has to stay in a (dry) dock and can't be operated resulting in a loss of '*off-shore time*' for the vessel. The cost of one day of loss of off-shore time for a specialized vessel can be as high as 500.000 NOK, making the increase in transportation costs due to the use of air freight service negligibly. The same argument is used by firm D which is 'more than willing to pay the double price' as long as the parts are delivered in time.

Another factor influencing the importance of cost as incentive of using air freight services is whether the firm or customer is paying for the transportation service. The multiple case study shows that there is no rule of thumb who is paying the costs for the transportation services. In the case of the specialized vessel building firm D, who is occasionally shipping spare parts to their constructed vessels, it is dependent on the guarantee period of one year on the vessels. Within the guarantee period the firm is responsible for the maintenance and thereby responsible for paying the transportation costs of spare parts. On the other hand firm A is always paying for its transportation services, but can be influenced by its customers in the form of penalty clauses. Being not able to deliver end products on time might involve monetary penalties, making it more '*affordable*' for firm A to use air freight services instead of cheaper but slower modes of transport.

Besides the above discussed incentives which are related to the five attributes of air freight services, four of the five firms do not intend to use air freight services. In these firms air freight services are not planned, but only used in case of emergency, caused by delays or breakdowns. Air freight is not planned since other modes of transport such as road, rail and sea are capable of delivering the needed goods in the correct amount, with a good quality, and in the desired time frame at lower cost compared to air freight services.

7.5.2 Product characteristics

The range of products transported via air freight services by the case firms can be described in a variety of ways. The interview focussed on the type of commodity, function

of the transported products, and the product characteristics. Furthermore data has been collected concerning the importance of the products and parts transported via air freight services using the Kraljic product.

- ***Type of commodity***

The type of commodities transported via airfreight services by the case study firms is to a large extend influenced by the industry the research is aiming at; the electromechanical industry in Møre og Romsdal. Commodities transported by the case firms include electronic components, ship spares, thrusters, satellite antenna spare parts, off-shore vessel production- and spare parts, and crane and machinery parts. Even though the type of commodities are strongly related to the type of industry, the commodities transported via air freight services by the case firms are amongst the most frequently transported commodities by air freight services in both Norway and Worldwide (SSB 2011; Morell 2011).

- ***Function of the product***

Commodities transported via air freight services effectuate a range of functions in a firm's supply chain such as the function of raw material, production component, end product, and spare- and service part. The case study shows that the main function of commodities transported via air freight services in the electromechanical industry in Møre og Romsdal is spare- and service parts. Spare- and service parts are mostly transported to the firm's customers who financially own and operate the firm's '*principal*' product and are in need of spare- and service parts due to maintenance schedules, upgrades or unexpected breakdowns. In addition air freight services are used to transport production components into the manufacturing process. However the share of production components is minor compared to the transportation of spare- and service parts. The high amount of spare- and service parts transported via air freight services is possibly a result of the type of industry the research is focussing on. As stated in the introduction, the electromechanical industry includes "the development, manufacturing, assembly, installation and maintenance of products and parts which are based on electronic circuits and mechanical systems". It is likely that such electronic and mechanical systems are in need of after-sales spare- and service parts for maintenance and/or breakdowns and therefore drive the demand via air freight services.

A common shared characteristic of the end products manufactured by the case study firms is their high level of complexity. The end products are assembled in the production process from a large amount of individual components which all have an essential function in the final assembled product. For example the offshore and onshore heavy lifting cranes manufactured by firm E consists of between 2.500 to 3.000 individual components, of which most are sourced via external suppliers. The high level of external global sourced components needed to finalize the construction of one unit drives in general the demand for transportation services. Even when air freight services is not the preferred transportation mode, it is likely that due to delays in the production process, changes in the product design and other unexpected events the high number of individual components will drive the demand for air freight services.

In addition the case study reveals that the function of the commodities transported via air freight services, spare- and service parts, induce another form of demand for air freight services namely the transportation of tool boxes, also called '*pelicases'*. Firms B, C and E all indicated the usages of such tool boxes. The value of those tool boxes, which containing mainly specialized work tools, varies between 20.000 to 40.000 US$ and have a weight of over 100kg as indicated by firm C. Tool boxes are used by mechanics and service technicians for installing spare- and service parts on behalf of the firms. Due to their large size and heavy weight, tool boxes need to be transported in the belly hold of aircrafts as cargo and cannot be transported as hand luggage, in case the technician is travelling together with the spare- or service part.

- ***Product characteristics***

Literature states that the characteristics of commodities transported with air freight services in general includes a high value to weight ratio, both economical and physical perishable, low demand predictability and their compact physical characteristics in terms of size and density (Cech 2004; Leinbach and Bowen 2004; Yamaguchi 2008). Only one case study firm indicated to transport spare parts or end products with a high value to weight ratio via air freight services. In contrast firm E states that it is not uncommon that the costs of air freight transportation are higher than the value of the part or product itself. The other firms all stated that the main characteristics of the air freight transported parts and products is urgency. As can be concluded products and parts transported via air freight are not selected based on characteristics such as high value to weight ratio, perishability or

their compact size but on their level of urgency. Indeed, firm B indicated that in the past completely assembled azimuth thrusters have been transported via air freight services. This indicates that the product characteristics mentioned in the literature are not valid drivers of air freight demand for firms on the electromechanical industry in Møre og Romsdal.

- ***Product Life Cycle***

Broadly discussed in the literature and briefly in paragraph 4.1.1 is the shortening of product life cycles. Due to the shortening of product life cycles rapid time to market is required to keep customer satisfaction high. Since air freight services is the main transportation mode which can provide relatively fast transportation lead times, the shortening of product life cycles might result in an increased demand for air freight services. On the other hand there is little published research concerning the transportation needs during the different stages of a product's life cycle. Aitken and Towill (2003, p. 127) stating that "in order to compete in today's highly competitive marketplace supply chains must be engineered to match product characteristics and customer requirements. As products proceed through their life cycles these requirements dramatically change". Amongst others the optimal choice of mode and frequency of transportation is likely to differ as a product moves through its product life cycle (Aitken and Towill 2003).

Figure 7.1 depicts the product life cycle including the four stages a product shifts through. In the introduction stage there will be a slow growth rate in sales due to the low awareness of the product on the market. In the growth stage the product is widely accepted by the marketplace resulting in a strong and rapid sales increase. After the growth stage the products become mature resulting in a decrease in sales growth. Finally the marketplace will be saturated or the introduction of substitute products occurs and the product end in the decline stage where sales numbers even decrease more strongly (Trappey and Wu 2008).

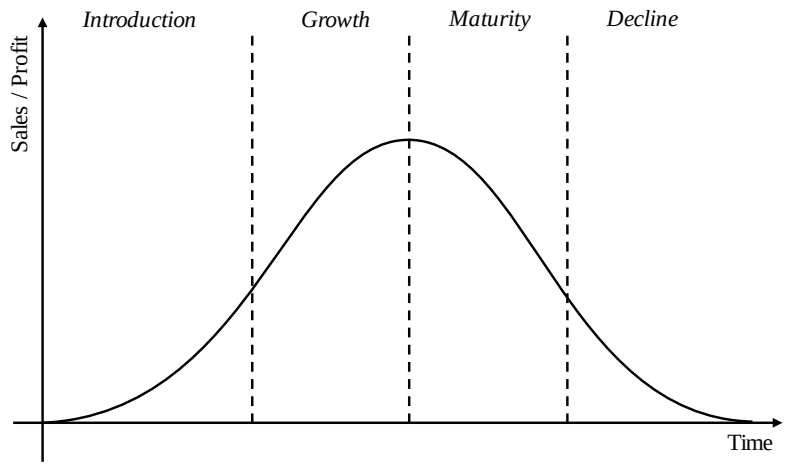

Figure 7-1: Product life cycle stages (composed by author based on (Trappey and Wu 2008).

Due to the different market's needs, the level of agility of the supply chain solution including the transportation solution of the products is likely to differ within the four stages. For example during the growth stage, where the largest amount of sales can be achieved, the focal firm should be able to react quickly on changes in market demand and should at any time be able to deliver the correct amount of products onto the market. On the other hand in the decline stage time to market is less important and demand is less likely to be stochastic.

The firms have been asked to indicate in which stage of the product life cycle end products transported via air freight services are. First if all not all firms are transporting end products with air freight services and could therefore not indicate the position of the product in its product life cycle. As indication both firm D and E manufacture products which have such dimensions, measured in size and weight, which is not feasible to transport them with air freight services. Fully assembled cranes manufactured by firm E can weigh up to 130 metric tonnes for example.

Thereby due to the type of manufacturing system, which is mostly tailor made and project based, it proved to be very difficult to classify end products into one of the four product life cycle stages. In the cases of firm B, D, and E the manufactured end products are in each single case unique and designed and constructed to meet specific customer specifications. These products are delivered only once to the customer and can reach life spans of over 30 years. In contradiction "short product life cycles have become more common in high technology and fashion-based industries which need to continuously

introduce new consumer products to remain competitive. New electronic products with more functions, faster speed, and finer quality are continuously being introduced and quickly replace models which may only be one year old" (Trappey and Wu 2008, p. 422). Thus it can be concluded that due to the type of industry and lack of available theory it is difficult nor impossible to define if the stage of the product life cycle in which end products are situated influence the demand for air freight services in the electromechanically industry in Møre og Romsdal.

- ***Importance of products in terms Kraljic Matrix***

The importance of a product, part or item for the firm is of importance when examining demand for air freight services. The questionnaire examined the importance of the product via the Kraljic matrix.

The Kraljic matrix is a purchasing portfolio in which the focal firm maximize its purchasing power. As can be seen in figure 7.2 items are examined based on their business impact and supply market complexity. The matrix defines four types of items (Harrison and van Hoek 2008):

- *Leverage*: items can be purchased from a large number of suppliers and have a large impact on the business result of the firm;
- *Strategic*: items can only be purchased from a limited number of suppliers whereby the items have a large impact on the business result of the firm;
- *Non-critical*: items can be purchased from a large number of suppliers and have a relative low impact on the business result of the firm;
- *Bottleneck*: items can only be purchased from a limited number of suppliers and have a relatively low impact on the business result of the firm.

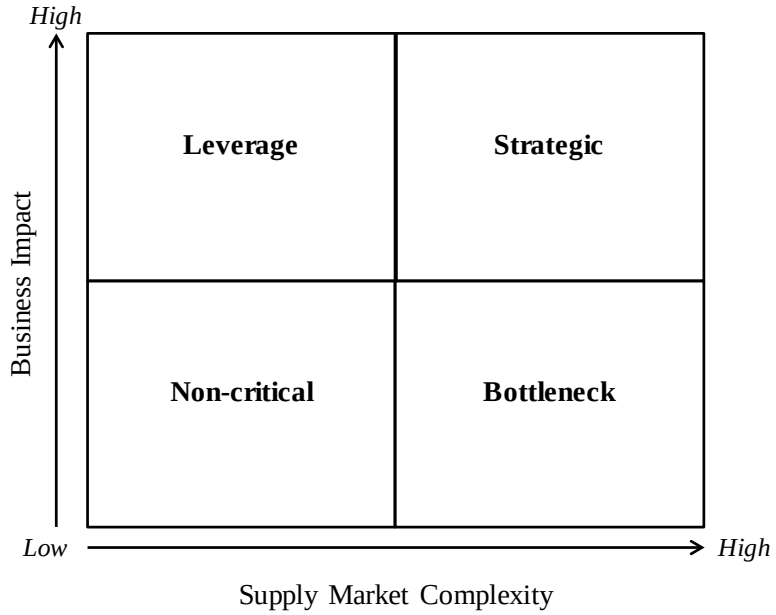

Figure 7-2: Kraljic purchasing portfolio matrix (composed by author based on (Harrison and van Hoek 2008).

Here one might argue that due to the high supply complexity and high business impact strategic product are more likely to drive air freight demand compared to non-critical products under certain circumstances. However if demand is highly stochastic other items such as leverage might also be in favour of being transported with air freight services.

Due to the mix of transported items via air freight services by the firms it proved to be difficult to analyse the case study results. Firm A indicated that the end-products they occasionally transporting with air freight services can be defined as leverage products, primarily based on the business impact for the firm. According firm D each single item has its unique characteristics in terms of business impact and supply complexity. Combined with the fact that firm D is scarcely using air freight services it could not specify which type of items are regular transported with air freight services. Firm E indicated to transport mainly strategic and bottleneck production parts and components with air freight services. Due to the lack of input from the firms it is difficult to state if one of the four items lead to a higher demand for air freight. However theoretically seen one might assume that strategic items will most likely lead to a higher demand for air freight services.

7.5.3 Firm's supply chain management

A diversity of aspect related to the design and management of a firm's supply chain could influence the use of air freight services. Aspects such as the supply chain structure, level of

vertical integration, decision makers, outsourcing of transportation services, and bottlenecks in the air freight supply chain will be discussed next.

- ***Supply chain structure***

Firms apply different supply chain structures based on order decoupling points as depicted in figure 7-3 which shows six order decoupling points. “The decoupling point separates the part of the supply chain that responds directly to the customer from the part of the supply chain that uses forward planning and a strategic stock to buffer against the variability in the demand of the supply chain” (Naylor 1999). As can be seen upstream from the decoupling point the supply chain is forecast driven (push supply chain) and downstream from the decoupling point the supply chain is market driven (pull supply chain). In push supply chains “costs are transmitted up the chain with little control over the cost structure of the entire chain” where pull supply chains “operates on the principal that the supply chain must be able to deliver a product to market at an affordable level” (Leinbach and Bowen 2004, p. 306).

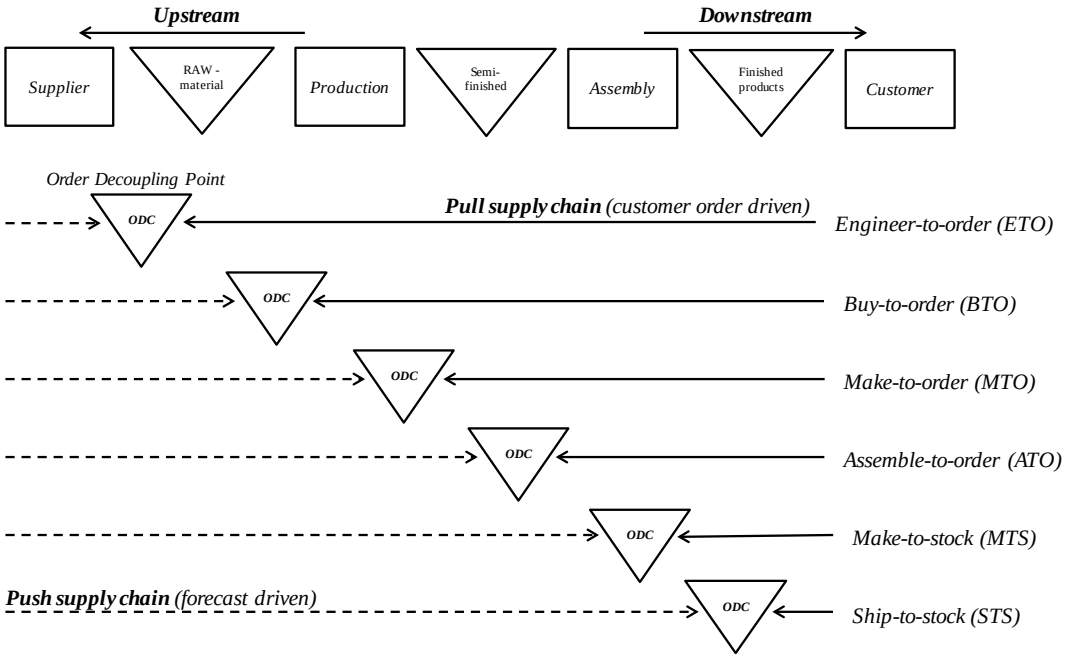

Figure 7-3: Order decouple points (compiled by author based on (Naylor 1999).

All the firms indicated to manufacture according to the make-to-order (MTO) or engineer-to-order (ETO) decoupling point (note: firm A is besides a MTO also operating several production lines according to the make-to-stock (MTS) decoupling point). In the ETO

supply chain the customer penetrates the supply chain at the design phase of a product. The ETO supply chain is “primarily associated with large, complex project environments in sectors such as construction and capital goods” (Gosling 2009, p. 741) which is also found in the case study firms. According to Naylor, Naim, and Berry (1999) ETO supply chains are characterized by the manufacturing of unique products that do not share necessarily the same RAW-materials, end users that are willing to wait a long time between order entry and order delivery, and demand for end products which is highly variable.

The service part of the supply chain should hereby also be taken into consideration. As discussed earlier a large part of the transported items via air freight services consist of spare- and service parts. The demand for such parts is highly customer driven with the presence of customer-supplier duality. However it is difficult to clarify if an ETO or MTO supply chain structure leads to a higher demand for air freight services than for example a MTS supply chain structure. Based on the high stochastic demand in customer order driven ETO and MTO supply chain structures compared to forecast driven MTS supply chain structures we can argue that pull supply chains will probably result in some demand for air freight services. The service part (spare- and service parts for repairs) of the pull supply chains in the electromechanical industry in Møre og Romsdal might thereby aggravate demand for air freight services.

- ***Vertical integration***

Vertical integration can be defined as the ownership, or at least control, of upstream suppliers and downstream customers by the focal firm (Mangan 2008). In case a firm is highly vertically integrated with its upstream suppliers, it might reduce its demand for air freight services. To a large extend this can be explained due to the improved information exchange between the focal firm and its upstream suppliers when vertical integrated. Increased information exchange can consist of data concerning e.g. demand forecasts, new product development and so on. By improving the information sharing of vital data between the focal firm and it suppliers not only the information flow will be most likely improved but also the physical goods flow. Inbound flows can be managed more effectively due to better forecasts resulting in less rush orders due to unexpected events. The importance of good relation- or partnerships with upstream suppliers is recognized by (Christopher 2000, p. 43) stating that “often it is the lead-time of inbound suppliers that

limits the ability of a manufacturer to respond rapidly to customer requirements". And as seen in the case study such unexpected events are one of the main drivers for the use of air freight services. One should keep in mind that the above described situation is dependent on e.g. if demand has a stochastic structure or not. Highly stochastic demand might drive a firms air freight demand even in vertically integrated supply chains due to the high probability of rush orders.

Other physical benefits of vertically integrated supply chains are discussed by Power (2005, p. 255) stating that "from the point-of-view of the movement of physical goods, an integrated supply chain offers the opportunity for firms to compete on the basis of speed and flexibility, while at the same time holding minimum levels of inventory in the chain".

Vertical integration is to some extend practiced by the case study firms. Firm E indicates to operate a highly vertically integrated upstream supply chain. Important suppliers are selected and ranked as '*partners'* in order to forecast demand better due to increased information sharing. Hereby it is important for firm E that their partner suppliers know what their plans are in terms of new products development, currently constructed products, new orders, and so on. Firm D has some vertically integrated suppliers which provide them with e.g. piping an electro services. In addition firm D is a dominant customer of its other non-integrated suppliers. Vertically integrated suppliers have a share of approximately 50 percent at firm A were firm B indicates to supply only from so called '*stand-alone*' suppliers. All firms concluded that a possible relation between their level of vertical integration and air freight usages is negative. Most firms stated that due to their relatively low air freight volume they could not estimate the effect of vertical integration on their demand for air freight services.

- ***Decision maker***

When defining the demand for air freight services, another important factor to examine is the decision making role of supply chain partners concerning the preferred transportation solution for a spare part or end-product. The main focus is put on spare- and service parts and end products since in these cases the end customer might have influence on the transportation solution suggested by the focal firm.

The case study shows that the focal firm is seldom the sole decision maker concerning the preferred transportation solution of a product or part. End customers can to some extend influence the decision with for example contracts which include penalty clauses as stated by firm A. In the case of large construction projects firm A might be selected to be the preferred supplier of illuminating products for the complete construction project. In case when firm A is not able to supply their products within the on forehand agreed deadline, a monetary penalty can be imposed by the end customer. Here firm A has to made the monetary trade-off between paying the penalty or increase production efficiency by using air freight services in order to receive production parts earlier than planned, where the latter option will lead to an increase in transportation costs. Thereby also the customer service level might positively influence firm A to use air freight services in order to satisfy customer demand and secure any possible future business with the end customer involved. This example shows how end customer preferences can influence the demand for air freight services of the focal firms involved in the case study. Contracts with monetary penalty clauses are also indicated by firm E as possible driver for air freight demand.

Besides contracts including penalty clauses the decision making process can also be influenced by guarantee periods such as in the case of firm D. Within the guarantee period of a manufactured vessel, firm D is responsible for the maintenance of the vessel and for repairs of unexpected breakdowns. Therefore within the guarantee period firm D is the solely decision maker of the used transportation mode. After the guarantee period the ship owners are responsible for the maintenance and repairs of their vessels and will therefore be the decision maker in terms of the transportation solution of spare- and service parts.

In the case of firm B the shipping manager is the decision maker on how spare- and service parts are transported. However, since the end customer is paying for the transportation service, it might influence the choice of transportation solution.

Finally the relation of the decision maker and demand for air freight services is quoted by firm E. Recently the firm has received orders from customers to build cranes in very short lead-times up to seven months. Normally the lead-time to build comparable cranes is significant longer. In order to satisfy customer demand the sales department of the firm sells the cranes for a higher price in consultation with the customer. The increased price covers the extensive use for air freight needed to shorten production lead-time. This

example shows how customer needs can drive the demand for air freight services even though the firm does not intend to use air freight services.

- ***Outsourcing of logistics activities***

As discussed in the literature, the main customers of airlines are freight forwarders (Nordang and Grimsbo 2000). In the local example of Kristiansund airport Kvernberget freight forwarders account approximately for 90% of the booking process of air freight services. According to Nordang and Grimsbo (2000) 10 years ago 62 percent of all air freight in Norway has been booked via a freight forwarder.

All the case firms indicated to outsource their logistic services in the form of air freight services. Thereby they indicated that the booking process is always performed by the freight forwarder or third party service provider. In order to explain this trend the case firms have been asked to identify why outsourcing of air freight services is preferred over managing the transportation in-house. The main reason for outsourcing air freight services for the case firms is to gain competitive advantage due to the better experience and network knowledge of the freight forwarder. By using the expertise of the freight forwarders the firms are able to increase their service levels and thereby their competitive advantage. In addition firm D stated that their annual air freight volume is too small to gain advantage by managing air freight services in house. Firm E indicates that their annual air freight volume is however large enough to manage air freight services in-house. Still the management of air freight services is outsourced since firm's E strategy is to focus on their core competence, the engineering and manufacturing of cranes.

These results are similar to the findings provided earlier in this report by Nordang and Grimsbo (2000) who mention that modest freight volumes, a lack of skills and knowledge of firms, the preference of airlines to cooperate with freight forwarders, and the fact that freight forwarders can offer better rates due to consolidation of shipments (groupage) driving firms to outsource the management of air freight services.

- ***Firm's level of satisfaction***

In general the level of satisfaction concerning the delivered service from the contracted logistic service providers is relatively high. For example firm A states that the price of a consignment is agreed before the consignment is performed. Therefore the firm faces

never the surprise of unexpected high costs. Firm B indicates to pay the premium price for air freight services but receives excellent quality. In addition the firm states it would be more expensive to hire a person to benchmark tariffs of several freight forwarders or service providers for each consignment to find the cheapest service. Firm C is more or less satisfied with the received service level. However the firm level of satisfaction is somewhat dependent on the destination and time. Satisfaction of shipments to smaller cities is less compared to shipments to larger cities and in terms of time, shipments through weekends tend to cause some more problems than shipments made during weekdays. At last firm D states it is not able to judge the performance of their outsourced air freight services because of their relatively low air freight volume. But the firm would expect outstanding service and quality due to the premium price which is paid for this transportation mode. Generally speaking the firms do not indicate a gap between the expected services and their received services from the service providers and freight forwarders.

- ***Bottlenecks and disruptions***

The presence of bottlenecks could possible influence the attractiveness and efficiency of the air freight supply chain, and therefore has a negative impact on the demand for air freight services. However the case firms indicated that there a no such kind of bottlenecks experienced which would withdraw the firms from using air freight services. Only relatively minor bottlenecks have been experienced by the firms.

In general the firms indicate that two types of bottlenecks have been experienced. The first experienced bottleneck is concerned with the infrastructure of the local airports in Møre og Romsdal. Routes served to and from Oslo are operated with Boeing 737-series aircrafts. These midsize, short range, narrow body aircrafts carry freight on the lower deck of the aircraft. The opening dimensions of the forward and aft cargo door size only allow cargo pieces with maximum dimensions of 0,89m x 1,22m (Boeing 2007). Both firm B and D, which are operating in the maritime industry, indicated that these dimensions occasionally form a constraint in their air freight usages. Besides the dimensions, also the maximum weight per single item of cargo (approximately 500kg) is indicated by firm B as a constraint. In order to avoid the constraint of the maximum allowed size and weight, firm B is transporting large items first via surface transportation to Frankfurt airport (FRA) in

Germany where the items are transported to their end destination with the use of larger freighter aircrafts such as the Boeing 747-F.

The second bottleneck experienced is related to the customs clearance process. When firm B is shipping consignments consisting of more than one pallet, it occasionally occurs that due to customs clearance, not all the pallets arrive simultaneously at their destination. In the case of spare- and service parts all the items consolidated in the shipment are needed to perform the repairs. Firm A is hereby stating that they have experienced delays due to customs clearance and thereby state that the disruptions caused by customs clearance are highly dependent on the country of destination and normally only occur with export shipments (especially to countries outside the EU). Customs clearance and the limited capacity of passenger aircrafts in terms of their cargo carriage as a bottleneck in the air freight supply chain is broadly described in the literature (Kasarda and Green 2005; Zhang and Zhang 2002; Morell 2011). The case study proves the presence of those bottlenecks in the air freight supply chain of firms operating in the electromechanical industry in Møre og Romsdal. It also proves that the presence of those bottlenecks almost do not influence the demand for air freight services.

At last firm E indicates that the frequency of flights from Molde airport Årø to Oslo airport Gardermoen does not fit their needs. The flights operated by Scandinavian Airlines and Norwegian are scheduled in order or to serve passenger needs. Thereby both the flights of Scandinavian Airliners and Norwegian are scheduled almost simultaneously leaving gaps in daytime with no flight to Oslo airport Gardemoen when most needed by firm E (i.e. in the early afternoon). This disadvantage of shipping freight with passenger aircrafts which serves networks optimized for passenger needs has been recognized in the scientific literature and is discussed earlier in this thesis.

Besides the occurrence of bottlenecks the firms were also asked to indicate how disruptions such as delays would influence the firm’s production lead times and the process of the end customers where the parts or end products are used. The production companies A, B and D are indicating that delays in the air freight supply chain in general are not causing serious disruptions in their production processes. Both firm B and D are manufacturing goods to order, where the production of an item represents often a large project which can take several weeks or months to complete. Therefore employees can

relatively easy switch between production projects. In this way the firms are adding flexibility into their production process to cover possible delays in the inbound goods flow. Only in the case where a construction project is close to finish delays in the air freight supply chain can have serious impacts on the delivery date of products worth millions of Norwegian Kroners. In case of Firm A, which is also partly operating a make-to-stock production system delays in the inbound flow of production parts transported with air freight services could be causing more serious disruptions in the production process, such as the hold of complete production lines.

7.5.4 Internationalization

According to the research performed by Leinbach and Bowen (2004) the level of internationalization is one of the main aspects of a firm influencing its demand for air freight services. The authors statistically proof that "distance associated with forward and backward production linkages emerged as the most important explanatory factor of air cargo usage" (Leinbach and Bowen 2004, p. 317). Hereby forward and backward production linkages include the geographical distance between a firm's production sites, final markets and its materials procurements sites. The larger the distance over which a firm's supply chain is stretched the more likely air freight usage gets.

The case study measured the firm's level of internationalization in terms of distance from its production site to the main end-customers and suppliers. Thereby firms could answer four possible levels of internationalization; local, regional, national, and international. Here local represents the town, regional the county, national the country, and international the entire world.

In terms of the geographical location of the suppliers, the majority of the firms are practicing a global sourcing strategy. The firms A, B and C all indicated to source their raw-materials and production parts from suppliers located at different parts of the world. One of these three firms, firm B, mentioned that even though they are sourcing from a global supplier network, the gross of their raw-materials and production parts are sourced on a local and national scale. Firm D stated to source from an extensive local supplier network. The extensive use of local suppliers by the companies B and D can be explained

through the presence of the (offshore) maritime industry cluster in Møre og Romsdal. As the yard director of company D states “due to the large maritime industry in this region, many suppliers for this industry have chosen to locate in a close proximity to their customers. Even suppliers which are not of a Norwegian origin have decided to locate in the region close to where the activities finds place”.

The same pattern of internationalization is found in the geographical location of the main customers of the firms. The main customers of the firms A, B, C and E are spread globally whilst the main customers of firm D are local. A note should be made in the local customers of firm D since they include ship owners. Ship owners might be located locally but a small share of the vessels purchased by those ship owners are operated on a global scale.

7.5.5 Materials management

The materials management aspects which have been examined during the case study will be discussed next and include new product design and inventory management (tools).

- ***Product design***

The earlier discussed limitations of air freight services in terms of maximum allowed size and weight per single item might influence the design of a product. When a firm on forehand knows that the to-be designed product has to be transported via air freight services, the firm might adjust the design of the product to make it suitable for air freight transportation. Modularization might be one of the practices used in the design of large items for example. Possible negative effects of the air freight size limitations could be a reduction in the functionality of the product.

None of the firms is taking the limitation of maximum allowed size of air freight consignments into account during the design process of a new product. The main rationale for this trend is the fact that the firms do not intent to use air freight services as transportation mode for their products. In addition firms on forehand have the knowledge that their products will not be suitable to be transported with air freight services even when the concept of modularisation is applied. The cranes of firm E are to some extend

modularised but still the individual modules are too large in size to be transported with air freight services.

- ***Inventory management***

Air freight services to some extend can be seen as a substitute product for inventory. The role of air freight as a substitute product for inventory is recognized by Leinbach and Bowen (2004, p. 301) stating that "air cargo services, as part of a supply and value chain management strategy, can contribute to both product cost and/or differentiation: through inventory minimization in the case of the former and speed-to-market in the case of the latter". Due to the fast lead-time of air freight services compared to other land and sea based transportation modes, firms using air freight services are able to maintain lower stock levels since replenishments cycles can be fulfilled more frequent and in smaller batches. The result of the lower stock levels is likely to reduce inventory costs including inventory carrying costs (capital costs, storage space costs, and inventory risk costs) (Efstathiou and Anderson 2000). The relation between inventory levels and the use of air freight services is recognized by Morell (2011, p. 12) stating that "manufactures' inventory to sales ratio reductions are often associated with increases in air freight traffic and vice versa. When inventory gets too low re-stocking takes place and this might initially be best done by using air freight".

The case study shows that none of the firms are using air freight services in their inventory management strategy nor recognize air freight services as a substitute product for it. For example for each crane firm E is manufacturing a logistics plan is developed. This plan shows in detail when certain parts or components from suppliers are needed in the production process. Since the long production lead-time of the cranes manufactured, parts from suppliers are as much as possible consolidated and send via full truck loads (European suppliers) or full container loads (global suppliers) to reduce shipping costs. Hereby also no production philosophies such as just-in-time are used as also indicated by firm D which states that "perfect just-in-time is almost not possible in our shipyards due to the chance of delays; some small suppliers are just not reliable enough". The link between air freight services, just-in-time and inventory costs is recognized by Morell (2011, p. 40) stating that the high frequency of planned air freight shipments might be beneficial for just-in-time production philosophies, but here "the cost disadvantage of smaller shipments is offset against the lower cost of handling a large inventory". Also firm A which central

European warehouse is located in Molde does not recognize air freight services as a substitute for inventory including a possible reduction in inventory costs.

- ***ABC analysis***

From origin the ABC analysis is an inventory categorization tool used in materials management. Items in stock are categorized as A, B, or C item dependent on their importance for the firm in terms of profitability. A frequently used ABC categorization is depicted in the table below:

Categorization	***Description***
A item	*20% of the product assortment accounts for 80% of the firm's turnover*
B item	*30% of the product assortment accounts for 15% of the firm's turnover*
C item	*50% of the product assortment accounts for 5% of the firm's turnover*

Table 7-3: Item categories according to the ABC analysis.

One might argue that since A-classified products have a large impact on the profit of a firm, tight control is needed. Thereby the firm has to make sure this product is available at any time since the potential loss of '*no-sales*'. Therefore based on this argument A products are more likely to be transported with air freight services seen the business importance of those items compared to C products.

However also the availability of transportation possibilities and the planning horizon should be taken into consideration. When the demand of an item is known long before it is needed i.e. when the planning horizon is long, an item don't necessary need to be transported with air freight services. If demand is not stochastic other modes of transportation (if available) with longer transportation lead-time could also prove satisfactory. In this case A products with a non-stochastic demand will have no impact on the demand for air freight services.

Most of the respondents were not able to categorize their products into A, B, or C items and to link the classification of their products to their demand for air freight services. Firm E provided the most usable input regarding their ABC analysis strategy. As indicated the manufacturing lead time of cranes build by firm E can be as long as several months. Therefore demand in the form of inbound production parts and components can be planned

well in advanced. A logistics master plan is made in order to consolidate the needed parts into full truck loads (from EU suppliers) and full container loads (global suppliers) to reduce transportation costs as much as possible but still receive the parts and components on time in the manufacturing process. Because of the great importance of A parts and components those are extra carefully monitored by firm E to make sure they arrive in time. The intensified monitoring of A classified items leads to less demand for air freight services since the A items are more likely to be transported with conventional transportation modes such as road and sea.

In addition firm E states that during the manufacturing process the classification of items might change. For example items with a C classification at the start of the manufacturing process might change into A items at the end of the manufacturing process since it might delay the delivery of the end product to the customer. From this example it can be concluded that the importance of a product according to the ABC analysis can have positive as well as negative impacts on a firm's demand for air freight services.

7.5.6 Strategy

Finally the firms have been asked to indicate how the quality and availability of air freight services has influenced their strategy based on location decision, firm growth, and the necessity of the availability of air freight services in order to stay in business.

- ***Location decision and growth***

The availability of air freight services in the form of airport infrastructure including a network of flights providing freight services might influence the location decision of firm's manufactories and warehouses. This is recognized by Grosso and Shepherd (2010, p. 9) stating that "advanced manufacturing firms are also increasingly locating at sites near air cargo hubs to optimise their location strategies".

Even though the influence of the availability or lack of availability of air freight services in the location decision of manufacturing firms is recognized in the scientific literature, none of the case study firm's location decision was influenced by the availability of air freight

services. This might be declared by the fact that all firms do not intent to use air freight services in their supply chain management strategy and only use it in case of urgency.

- ***Business continuity and firm's growth***

On the questions if the availability and quality of air freight services impacted the business continuity and the firm's growth the five firms gave contradictory answers. Firm B, C, and E indicated that the availability of air freight services is to varying degrees impacting their business continuity and growth. Firm B states that air freight services are especially vital for their after sales service and spare parts industry but only play a minor role in the manufacturing parts inbound flow. Firm C is also indicating that the fast shipping of spare parts including technicians is vital to maintain high customer satisfaction levels. By quickly responding on customer demand the satellite communication on the vessel can be recovered on very short notice which is only possible with the support of an extensive air freight network. Due to the opening of factories in both Korea and Poland air freight services have become vital for firm E. On the other hand firm A and D both indicate that their business would survive without the availability of air freight services. In addition firm D stated that air transport with regards to passengers is much more important for the firm. This because of clients which are frequently visiting the yard to monitor the progress and quality of the manufacturing process. It can be concluded that the availability of air freight services is important for firms in the electromechanical industry in Møre og Romsdal especially with regard to the after service and spare parts business.

7.6 Conclusion and reflections

Now the case study results have been extensively discussed a conclusion can be draft concerning the role of air freight services in supply chain management strategy of firms operating in the electromechanical industry in Møre og Romsdal. Thereby the results will also be compared findings from the scientific literature.

7.6.1 Case study findings

The structure and content of the case study design has been based upon the earlier developed conceptual theoretical framework. Therefore it is adequate to construct the

conclusion based on similarities and differences between findings in the '*theoretical perspective*' and the '*real world perspective*'.

A revised version of the conceptual theoretical framework has been configured which summarises the case study results and is depicted in figure 7-4. Were the initial theoretical framework interlinked attributes affecting demand for air freight services according to scientific research, the revised model interlinks attributes affecting demand for air freight services of firms operating in the electromechanical industry in Møre og Romsdal.

The attributes marked with a green tick are positively influencing a firm's demand for air freight services (i.e. drivers) and attributes marked with a red cross are negatively impacting a firm's demand for air freight services or do not have any impact on air freight demand. Some of the red cross attributes can thereby be appointed as bottleneck. In addition a small number of attributes can both positively and negatively influence a firm's demand for air freight services. Those are marked both with a green tick and a red cross. The attributes in the boxes *international regulations, national regulations, international trade* (except customs), and *infrastructure* are mainly based upon findings of scientific literature. These attributes have been used to describe the '*environment*' in which firms and the air freight industry are operating and have not been covered in the case study. The results in the framework are self-explanatory combined with the extensive explanation given in the case study results and theoretical part of this thesis and will be therefore not discussed further in detail.

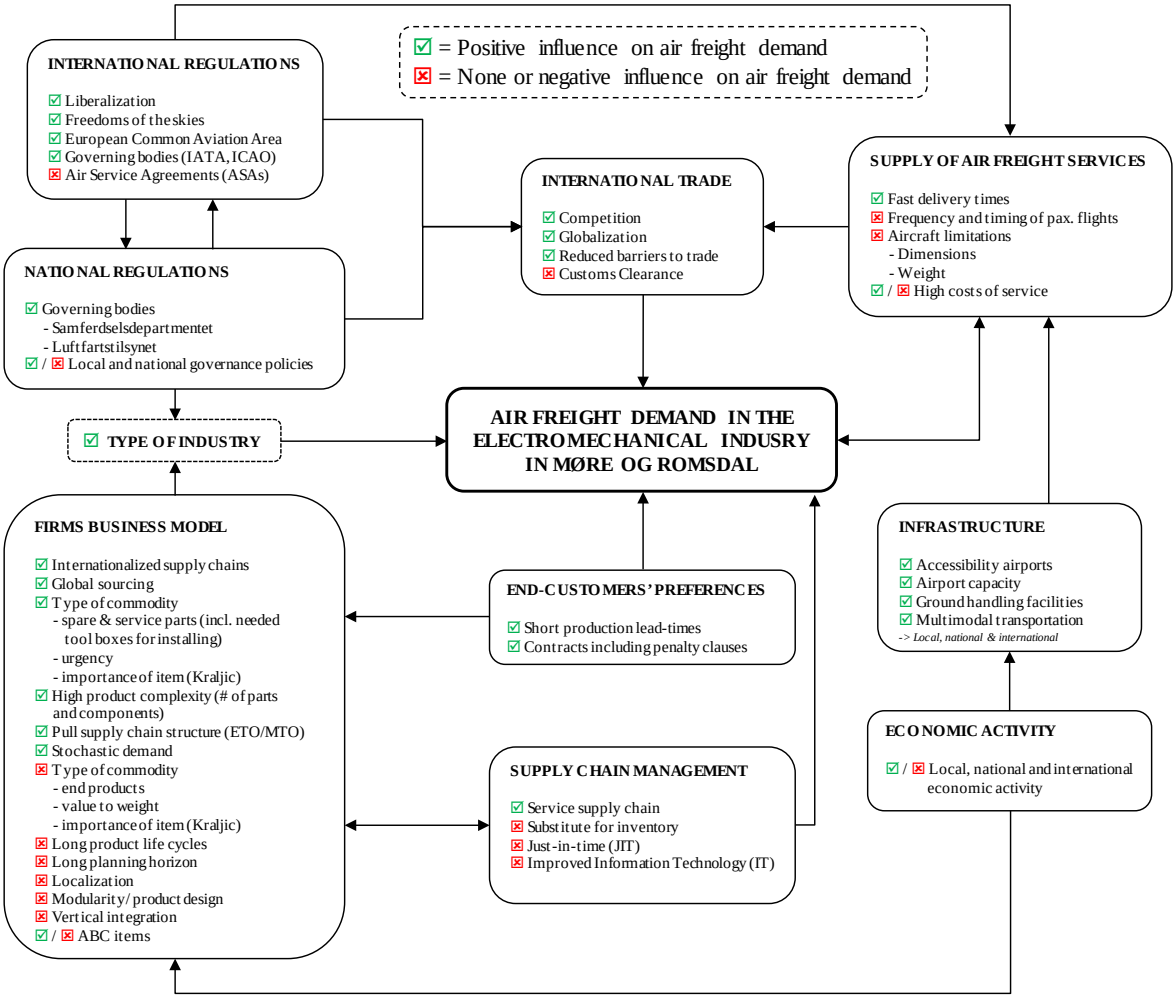

Figure 7-4: Revised conceptual theoretical framework based on case study findings.

7.6.2 Case study results versus scientific literature

By comparing the case study results with the obtained information retrieved from scientific literature a set of commonalities and differences can be found. The main commonalities between the case study results and scientific literature are trends such as internationalized supply chains, global sourcing, increased customer requirements and shorten production lead times which all have a positive influence on air freight demand. Observed differences in the electromechanical industry in Møre og Romsdal compared to scientific literature are amongst others the absence of the value-to-weight characteristic, long product life cycles, and the absence of just-in-time. Differences can to a large extend be declared by the industry the research is aiming at. Many of the described attributes are directly influenced by the type of industry the research is aiming at.

8. Reflections on the research questions

Before drawing the conclusion, chapter eight will provide the necessary reflections on the research questions. Since the broad content covered by the research questions and their explanatory power on the developed conceptual theoretical framework the answers on the research questions will be briefly discussed in this chapter. The concise answers on the research questions are to a large extend constructed based on the multiple case study findings and where needed complemented with theoretical perspectives obtained from the scientific literature.

1. How does the availability and quality of air freight services influence the competitive strength of firms, and does it impact strategically decision making within a firm?

The availability and quality of air freight services in the electromechanical industry in Møre or Romsdal does impact the competitive strength of firms on a moderate level. Firms gain the most competitive advantage by the possibility to ship spare- and service parts with very short lead-times to their customers. Hereby the firm is able to maintain a high level of customer satisfaction. Furthermore it enables firms to operate more effectively on a global market by being able to reduce transportation lead-times between international upstream suppliers and downstream customers. It should be noted that the impact is only minor since firm's do not intent to include air freight services in their supply chain strategy. Strategically decisions are rarely influenced by the availability and quality of air freight services.

2. What are the characteristics of the demand for air freight services in the electromechanical industry in the Møre og Romsdal?

The main characteristic of demand for air freight services of firms operating in the electromechanical industry in Møre og Romsdal is that almost all items transported with air freight services are urgently needed. Furthermore demand for air freight services is to a large extend driven by the customers of the focal firm in the form of demand for after sales services i.e. spare- and service parts. Demand for inbound production parts and components only has a minor share since often demand for production parts and components is not stochastic.

a. Which firms are extensive air freight service users in terms of value and weight of the transported items?

A broad range of firms located in Møre og Romsdal are making use of air freight services in relation to the airports of Ålesund, Kristiansund, and Molde. According to the ground handling firms of those three airports the most frequent users of air freight services are mainly firms who are active in the maritime, oil and gas, and offshore industry in Møre og Romsdal. Hereby one can think of firms such as supply bases and manufactures of propulsion systems, offshore vessels, maritime equipment, and so on. Besides those frequent air freight users there are a large number of firms who occasionally use air freight services. Amongst others they include car dealers and repair shops, retail stores, fish related firms and construction firms. This overview of air freight users is based on air freight usage measured in number of shipments were it was not possible to obtain information of common users based on the value and weight of their consignments.

b. What are the characteristics of the items which are transported by air freight service, and are there any similarities or differences between these items?

The main type of commodities transported with air freight services proved to be mechanical and electronic parts and components such as crane parts, ship spares, and machinery parts. These types of commodities are distinctive for the researched industry and are likely to differ in other types of industry. The main function of items transported with air freight services are spare- and service parts followed by production parts and components and end products. The high level of spare- and service parts transported with air freight services is also likely to be a distinctive characteristic of the electromechanical industry. Spare and service parts occur due to need of maintenance, updates and the chance of breakdowns of mechanical parts and components in the end products which need to be replaced and repaired on a short notice. The main common shared characteristic of items transported via air freight services in the electromechanical industry in Møre og Romsdal is their level of urgency. Parts and products are only transported via air freight services when they are urgently needed in the production process or by customers in order to keep their product operative. Noticeable is the absence of the value to weight characteristic which frequently is argued to be the main product characteristic in scientific literature. None of the firms indicated to select items based on their value to weight ratio.

3. How are those air freight services demand characteristics related to the incentives for extensive users to select air freight services instead of road, rail or sea transportation for their items?

There is a clear link between air freight service demand characteristics and the incentives of firms to select air freight services. Due to the high level of urgency of items transported with air freight services lead time is the most important incentive for firms in using air freight services instead of other modes of transport. Hereby demand for air freight services is linked to the after sales service in the form of spare and service parts. This makes the higher costs of air freight services compared to other modes of transportation negligibly compared to the high cost of breakdown for the firm's customers.

a. How do costs, delivery time, frequency, security and the quality of air freight services influence the transport mode choice for the firms?

The fast delivery time of air freight services compared to other modes of transportation such as road, rail and sea is the main motive for firms in the electromechanical industry in Møre og Romsdal to select air freight services. Air freight is usually selected as transportation mode when other modes of transportation are not able to deliver the items in the desired lead time. The higher costs level of air freight services compared to other modes of transportation does not withdraw firms of using air freight services. The monetary costs of not having the required parts, components or products in the desired lead time are significantly higher making the increase in transportation costs negligibly. The importance of fast delivery times indicates the clear relationship with the product characteristic of urgency. Since air freight is mainly used to transport items which are urgently needed it is obvious that fast delivery time is the main incentive for firms to use air freight services. Frequency, security and quality only have a modest influence on the choice of transportation mode of firms.

b. Are there besides the abovementioned measures other important incentives for firms to make use of air freight services?

No other incentives different than the above discussed incentives of cost, delivery time, frequency, security, and quality where mentioned by the firms. However several firms

mentioned the requirement that mechanics and technicians should be able to travel along the same network accompanying the spare- and service parts, including their high value tool boxes.

4. Is the amount of air freight usage related to specific aspects of a firm's structure and operation?

The level of air freight usages is clearly related to specific aspects of a firm's structure and operation. Where some attributes negatively influence demand for air freight services others have a clear positive influence. Positively influencing business attributes are amongst others internationalized supply chains, a pull supply chain structure, and a high level of product complexity. Business attributes which negatively influence a firm's demand for air freight services are amongst others a high level of vertical integration, the absence of the just-in-time philosophy, and long product life cycles.

a. How do production characteristics like, process, network and strategy influence the use of air freight services?

The design of the production process does influence the use of air freight services. Due to long manufacturing lead times and the engineer-to-order and make-to-order decoupling points the demand for production parts and components can be planned well in advance (even though demand might by stochastic). This enables firms to consolidate parts and components and transport them with cheaper modes of transportation such as road and sea.

b. What is the impact of customer preferences on the level of usage of air freight services of the firms?

Customer preferences do impact a firm's demand for air freight services in several ways. First of all due to the use of contracts. Firms in the electromechanical industry operate mostly an engineer-to-order supply chain which is characterised by large project based manufacturing processes. Often contracts are agreed upon between the firm and the customer concerning the design, specifications, and delivery of a product, including monetary penalty clauses if the firm cannot deliver the agreed service. Delays in the production process might result in an increase in the use of air freight to cover the lost time

and still being able to deliver the end product to the customer within the agreed delivery date and thereby outrun monetary penalties.

Secondly customers can influence a firm's demand for air freight services by their order specifications. As said products produced in the electromechanical industry are often specific engineered and manufactured according customer requirements where manufacturing can take up to several months. Thereby customers are increasingly demanding in terms of short lead-times between the point of ordering and receiving the end product. Air freight services are used as solution by the manufacturing firms to satisfy those customer requirements. This will increase the demand for air freight services of the focal firm.

Finally it is not uncommon in the electromechanical industry that customers change the specifications of their ordered product during the manufacturing process without adapting the final delivery date. The late changes often leave no choice for the manufacturing firms to use air freight services in order to not delay the delivery date of the final product.

c. Does the size and level of internationalization of the companies influence the use of air freight?

The level of internationalization of firms measured in the geographical distance between the focal firms and its upstream suppliers and downstream customers do influence a firm's use of air freight services. Firms with a local supplier network and local customers proved to be less intensive users of air freight services compared to firms with a global supplier network and global customers. Due to the increased transportation distances caused by the internationalization of supply chain networks air freight is more often used to cover the long transportation lead times. But due to the long manufacturing lead-times of products manufactured in the electromechanical industry, the inbound flow of production parts and components can be planned long before the parts are needed. This long planning horizon diminishes the need for air freight services caused by the longer geographical distances between supply chain partners.

9. Conclusion and further research

Chapter nine represents the last part of this report and will provide first of all the conclusion of the research based on the scientific literature and the case study results. After the conclusion the research limitations and points for further research will be discussed.

9.1 Conclusion

The main aim of the research has been to explain the role of air freight services in a firm's supply chain management strategy. The research has thereby put a large emphasize on describing how a specific set of business attributes and supply chain characteristics are influencing a firm's demand for air freight services. Designed as a multiple case study the research focused primarily on the electromechanical industry in Møre og Romsdal.

First the research showed the increasing importance of air freight as transportation mode in international trade due to the introduction the just-in-time phenomena, the shortening of product lifecycles, the increased level of internationalization of upstream and downstream supply chain networks, and the liberalization of air freight services. Thereby supply chains are becoming increasingly agile in order to satisfy intensified customer expectations.

The air freight supply chain which is the backbone in providing air freight services has proved to be a complex network consisting of a large number of supply chain actors which have to successfully coordinate the physical movement of freight and extensive exchange of information. The entire process is governed by a large number of bilateral and multilateral regulations which are often based on passenger transportation needs. This impacts the quality and service or air freight services since air freight services have different needs in terms of network, timing, and capacity compared to passenger services.

Air freight services in Norway are provided through a dense network of 46 Avinor operated airports spread throughout the country, of which four located in Møre og Romsdal. In 2011 these four airports handled approximately one thousand tonnes of freight representing only a minor 1.5 percent of the total amount of freight transported via air freight services in Norway.

The case study results showed that none of the firms in the electromechanical industry in Møre og Romsdal planned to use air freight services in their supply chain management strategy. Air freight services are only used when production parts or spare- and service parts are urgently needed and conventional transportation modes such as road, sea and rail are not able to deliver the products in the desired lead-time. The fast lead-time of air freight services has therefore been indicated as the most important attributes to select air freight services as transportation mode.

The research indicates that the use of air freight services is positively influenced by a limited number of business- and product attributes. It showed that mainly the high level of internationalization and resulting global sourcing are driving a firm's demand for air freight services. Furthermore the examined type of commodity and industry proved to have a positive influence on the demand for air freight services in terms of the generation of demand for spare- and service parts.

In addition a much broader range of business attributes showed to have a negative impact on the demand for air freight. Amongst others those include the long product life cycle of products manufactured in the electromechanical industry, the engineer-to-order decouple point, vertically integrated upstream supply chains and the absence of the just-in-time phenomena. These attributes are likely to be related to the specific 'project based' industry which has been examined.

In addition it was found that there is gap between the scientific literature and the case study findings. Overall it seems that the type of industry and its specific characteristics has a large influence on the demand for air freight services. As final statement it can be said that the role of air freight services in the supply chain management strategy of firms in the electromechanically industry is small. However especially in the transportation of critical needed spare and service parts air freight services are indispensable in order to keep customer's processes operative and to maintain high customer service levels.

9.2 Research limitations

The research faced some limitations of which the main limitations affecting the quality of the findings will be discussed in this section.

First the multiple case study has been performed over a relatively small sample size of five firms. Including more firms into the case study would make the results more representative for the complete electromechanical industry in Møre og Romsdal. Because of the small sample size the results research could not be statistically proven. Even though it has not been the aim of this research to statistically proof the relationship of a set of business attributes on the demand for air freight services, it would definitely helped to strengthen the results of the research.

Secondly the research showed that attributes influencing demand for air freight services are to a large extend dependent on the type of industry examined. Especially the type of commodity and its related characteristics have a large influence on the outcome of the research. As a result the research findings can only be generalized on a very limited scale, especially on an inter-industry base.

9.3 Further research

The research covers a large research area including a wide variety of supply chain management related topics which has been to link to the demand for air freight services. Several of those topics have been scarcely discussed in scientific literature and could be examined in further detail. Those topics include the effect of the different stages of the product life cycle on the decision of the optimal transportation mode and the effect of vertical integration of supply chains on air freight demand.

Secondly the case study part of the research examines five firms who are users of air freight services. It could be interesting to perform a similar research and include firms who do not use air freight services to examine why those firms have no demand for air freight services. A similar set of business attributes as used in this research could be examined to

see how certain firm aspects influence or not influence a firm's demand for air freight services.

Third, as discussed in the limitations section a larger sample size of the case study could strengthen the results of the research. A point for further research might be to design a similar '*cross-industry*' case study. As seen in the results of this research demand for air freight services is to a large extend influenced by the type of industry. By designing a case study which covers multiple industries, results could be compared to indicate differences in air freight demand in different industries. Thereby the results could be generalized on a broader scale making the research more usable for scientific researchers.

Finally a further assessment of all the above mentioned topics could lead to a better understanding behind the drivers of demand for air freight services.

Appendix

Appendix A: Air freight volume Norwegian airports operated by Avinor in 2011.

	Domestic		International				
Airport	**Import**	**Export**	**Import**	**Export**	**Total**	**Share**	**County**
1. Oslo, Gardermoen	2.914	6.063	25.115	35.863	69.956	80,6%	Oslo
Large Airports							
2. Bergen, Flesland	1.572	981	320	476	3.349	3,9%	Hordaland
3. Stavanger, Sola	1.172	582	584	859	3.197	3,7%	Rogaland
4. Trondheim, Værnes	1.136	656	25	19	1.836	2,1%	Sør-Trøndelag
Regional Airports							
5. Trømso, Langnes	775	1.071	7	163	2.017	2,3%	Troms
6. Bodø	674	469	-	5	1.148	1,3%	Nordland
7. Svalbard, Longyær	209	344	190	65	808	0,9%	Svalbard
8. Ålesund, Vigra	***230***	***454***	***11***	***9***	***704***	***0,8%***	***Møre og Romsdal***
9. Kirkenes, Høybuktmoen	306	208	0	-	515	0,6%	Finnmark
10. Harstad-Narvik, Evenes	324	113	1	0	438	0,5%	Nordland
11. Kristiansand, Kjevik	201	105	10	14	330	0,4%	Vest-Agder
12. Molde, Årø	***172***	***150***	***-***	***2***	***325***	***0,4%***	***Møre og Romsdal***
13. Alta	246	34	1	-	282	0,3%	Finnmark
14. Haugesund, Karmøy	157	81	7	1	245	0,3%	Rogaland

	Domestic		International				
Airport	**Import**	**Export**	**Import**	**Export**	**Total**	**Share**	**County**
15. Kristiansund, Kvernberget	***147***	***50***	***2***	***1***	***200***	***0,2%***	***Møre og Romsdal***
16. Lakselv, Banak	55	4	21	21	101	0,1%	Finnmark
17. Bardufoss	49	2	-	-	52	0,1%	Troms
Local Airports							
18. Hammerfest	145	20	-	-	165	0,2%	Finnmark
19. Mo I Rana, Røssvoll	135	16	-	-	150	0,2%	Nordland
20. Vadsø	97	26	-	-	123	0,1%	Finnmark
21. Røros	54	53	8	7	122	0,1%	Sør-Trøndelag
22. Mosjøen, Kjærstad	56	21	-	-	78	0,1%	Nordland
23. Brønnøysund, Brønnøy	44	27	-	-	71	0,1%	Nordland
24. Sandnessjøen, Stokka	44	15	-	-	59	0,1%	Nordland
25. Svolvær, Helle	39	14	-	-	54	0,1%	Nordland
26. Leknes	43	6	-	-	49	0,1%	Nordland
27. Stokmarknes, Skagen	36	6	-	-	41	0,0%	Nordland
28. Førde, Bringeland	28	11	-	-	39	0,0%	Sogn og Fjordane
29. Honningsvåg, Valan	35	2	-	-	37	0,0%	Finnmark
30. Ørsta-Volda, Hovden	***23***	***10***	***-***	***-***	***34***	***0,0%***	***Møre og Romsdal***
31. Florø	24	7	-	-	31	0,0%	Sogn og Fjordane
32. Sogndal, Haukåsen	21	10	-	-	31	0,0%	Rogaland
33. Båtsfjord	25	2	-	-	27	0,0%	Finnmark
34. Narvik, Framnes	24	3	-	-	26	0,0%	Nordland
35. Sandane, Anda	22	3	-	-	25	0,0%	Sogn og Fjordane

	Domestic		International				
Airport	**Import**	**Export**	**Import**	**Export**	**Total**	**Share**	**County**
36. Vardø, Svartnes	16	1	-	-	17	0,0%	Finnmark
37. Mehamn	15	2	-	-	17	0,0%	Finnmark
38. Namsos	13	2	-	-	15	0,0%	Nord-Trøndelag
39. Andøya, Andenes	11	3	-	-	14	0,0%	Nordland
40. Berlevåg	10	2	-	-	12	0,0%	Finnmark
41. Rørvik, Ryum	10	2	-	-	12	0,0%	Nord-Trøndelag
42. Sørkjosen	7	1	-	-	8	0,0%	Troms
43. Hasvik	5	1	-	-	6	0,0%	Finnmark
44. Værøy (heliport)	3	1	-	-	4	0,0%	Nordland
45. Røst	1	0	-	-	2	0,0%	Nordland
46. Fagernes, Leirin	0	0	-	-	0	0,0%	Oppland
Oslo airport	**2.914**	**6.063**	**25.115**	**35.863**	**69.956**	**80,6%**	
Large airports	**3.880**	**2.220**	**929**	**1.353**	**8.382**	**9,7%**	
Regional airports	**3.546**	**3.086**	**250**	**281**	**7.163**	**8,3%**	
Local airports	**986**	**266**	**8**	**7**	**1.266**	**1,5%**	
Avinor Total	**11.326**	**11.635**	**26.303**	**37.504**	**86.767**	**100%**	
Avinor Total (%)	**13,1%**	**13,4%**	**30,3%**	**43,2%**	**100%**		

Table A-1: Air freight volume Norway 2011 (Avinor 2011).

Appendix B: Schematic overview multiple case study results.

	Firm A	***Firm B***	***Firm C***	***Firm D***	***Firm E***
Firm's characteristics					
Industry	Electronics	Maritime	Communication	Shipbuilding	Maritime
Type of products	Illuminating products	Thruster systems	Antennas	Offshore vessels	Offshore cranes
Main office location	Molde	Molde	Ålesund	Aukra	Molde
Production location	Molde	Molde	Ålesund	Aukra	Hjelset
Number of employees in interviewed BU	400 FTE	265 FTE	140 FTE	127 FTE, 100-300 flex	62 FTE (Hjelset)
Number of employees in total organisation	1.500 FTE	265 FTE	1.500 FTE	8.500 FTE	32.000 FTE
Operating result (2010)	136,9 million NOK	147,7 million NOK	9,4 million NOK	717,4 million NOK *	3,8 million NOK
Firm structure & supply chain management					
Type of production system	Make to stock & order	Engineer/make to order	Make to order	Engineer/make to order	Engineer to order
Air transport in-house or outsourced	Outsourced	Outsourced	Outsourced	Outsourced	Outsourced
Motives for outsourcing	Service level and quality	Experience and network	Network and expertise	Expertise and time	Focus on core business
Transportation solution decision maker	Firm with influence of client	Firm with influence of client	Firm	Depends on guarantee period	Firm with influence client
Influence on the location decision of the firm	No.	No.	No.	No.	No.
Level of vertical integration with suppliers	Medium level of integration	Low level of integration	N.A.	Medium level of integration	High level of integration
Geographical location of main suppliers	International	International	International	Regional and national	International
Geographical location of main customers	International	International	International	Regional and national	National and international
Experienced bottlenecks in air freight services	No bottlenecks	Customs and dimensions	Need always OSL airport	Dimensions (size & weight)	Dimensions, frequency
Proposed improvements for air freight services	No specific improvements	No specific improvements	No specific improvements	No specific improvements	Frequency of flights
Firm usages of air freight services					
Incentives for using air freight services	Delivery time & quality	Delivery time and quality	Delivery time & security	Delivery time	Delivery time
Intensity level of air freight usages	Less than 5 items per week	Between 5 and 10 per week	Between 5 and 10 per week	Less than 5 items per week	More than 10 per week
Share of air freight in terms of volume	Import 10% Export 5%	Import 10% Export 30%	Import - Export -	Import < 1% Export < 1%	Import 5% Export 10%
Share of air freight in terms of value	Import 1% Export 1%	Import - Export -	Import - Export -	Import < 1% Export < 1%	Import 5% Export 10%
Air freight services as substitute for inventory	No	No	No	No	No

	Firm A	***Firm B***	***Firm C***	***Firm D***	***Firm E***
Influence on design of new products	No	No	No	No	No
Air freight enables global business expansion	No	Yes	Yes	No	Yes
Main used airport of origin	1. OSL 2. MOL	1. OSL 2. MOL 3. FRA	1. OSL 2. AES	1. OSL 2. MOL	1. MOL 2. OSL 3. AMS
Main used airport of destination	Widely globally spread	Widely globally spread	Widely globally spread	Widely globally spread	Widely globally spread
* Total organisation					
Items transported with air freight					
Products shipped with airfreight	Raw materials, end products	Tool boxes, spares, products	Spare parts	Production and service parts	Production, spare, service parts
Characteristics of products and parts	Urgently needed	Urgently needed	High value	Urgently needed	Urgently needed
Air freight accompanied by service employees	No	Yes, services employees	Yes, technicians	Yes, mechanics	Yes, mechanics
Value of air freight shipped products	Low value	Low and high value	High value	High and low value	High and low value
Size of air freight shipped products	Small to medium	Small to large	Medium	Small to large	Small to large
Importance of items for firm (ABC analysis)	High and medium (A & B)	High importance (A)	High importance (A)	High importance (A)	High, medium, low importance
Importance of items for firm (Kraljic matrix)	Leverage products	N.A.	N.A.	Dependent on part/ product	Strategic and bottleneck
Product life cycle of air freight items	Growth and maturity	Decline	Introduction and decline	Introduction and decline	Introduction and growth

Table B-1: Summary table case study findings.

Appendix C: The air freight supply chain.

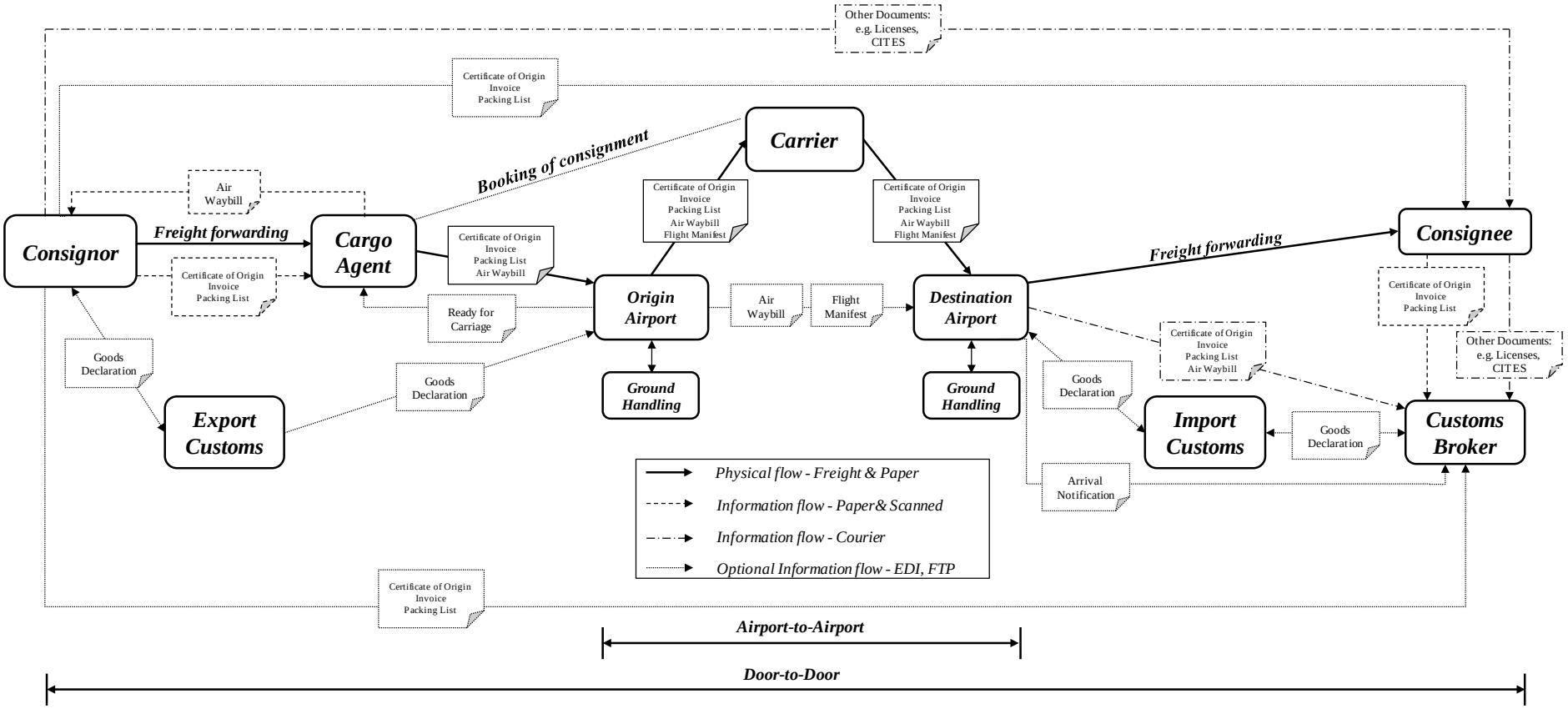

Figure C-1: Air freight supply chain (compiled by the author based on (IATA 2009).

Appendix D: Motives for using air cargo express services.

Service Attributes	**Definition**	**Rank**
A. Promptness		***7,85***
A1 Quick pick-up	On-time and quick pick-up from booking point	8,07
A2 Quick delivery	Quick delivery from puck-up point	8,64
A3 Network	Quick transportation networking	7,16
A4 Quick response	Quick response to customers request by i-net or phone	7,51
B. Accuracy		***8,25***
B1 On-time pick-up	On-time pick-up as per customer's request	8,34
B2 Pick-up service area	Wide pick-up service area	7,82
B3 On-time delivery	On-time delivery as per customers request	8,66
B4 Accurate delivery	Accurate delivery to address of shipment	8,16
C. Safety		**7,49**
C1 Handling	Handling by cargo characteristics	7,76
C2 Compensation	Compensation policy	7,74
C3 Problem solving	Cargo protection	8,16
C4 Information	Information management for cargo handling	6,55
C5 Facility	New facility	6,41
C6 Damage and loss	Delivery without damage or loss	8,33
D. Convenience		***7,63***
D1 Service area	Delivery to all area's	8,50
D2 Branch	Many branches	6,28
D3 Booking	Easy to book by internet and telephone	8,31
D4 Tracing	Easy to track and trace by internet and telephone	7,21
D5 Schedule	Convenient schedule for pick-up and delivery	7,83
E. Economic Efficiency		***8,68***
E1 Moderate price	Low price	8,78
E2 Variety rate	Offer many class rates	8,66
E3 Reasonable price	Reasonable price by volume and/or weight	8,54
E4 Rate policy	Offer benefits by track record of shippers or forwarders	8,72
F. Dependability		***7,87***
F1 Packing condition	Maintain packing condition for delivery	8,01
F2 Image	Image and reputation of the carrier	7,21
F3 Customs clearance	Seamless customs clearance	8,38

Table B-2 Users' expectation of service when selecting air cargo express carrier (Park, Choi, and Zhang 2009, p. 326)[8].

[8] 1 - being least important; 10 - being most important.

Appendix E: Interview guide case companies.

The interview guide is developed in accordance to guidelines described by Bryman and Bell (2011), chapter 18 *'Interviewing in Qualitative Research'*.

Facesheet

Name:_____ Organization: _____ Gender: ☐M ☐ F

Function:_____ Date of interview:_____

Transportation mode selection criteria

1a. Which attributes of air freight as a transportation mode makes you select air freight instead of other modes of transport like sea, rail or road for inbound and outbound transportation flows? On a scale from 1 to 7 (1= not important, 4= medium importance, 7= very important) how would you rank the importance of the following air freight characteristics?

	Inbound transportation	Outbound transportation
o Costs:	1 2 3 4 5 6 7	1 2 3 4 5 6 7
o Delivery time:	1 2 3 4 5 6 7	1 2 3 4 5 6 7
o Frequency:	1 2 3 4 5 6 7	1 2 3 4 5 6 7
o Security:	1 2 3 4 5 6 7	1 2 3 4 5 6 7
o Quality:	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Follow up question 1: Are there different incentives for using airfreight services for inbound or outbound transportation.

Follow up question 2: What is the reason of a particular high, medium or low importance ranking; i.e. what is the reason for your ranking?

1b. Are there besides the above mentioned attributes other attributes of air freight services which are important in your choice of using air freight services? (e.g. network, track & tracing, service level etc.).

- o No.
- o Yes, namely:

1c. If yes (1b), why are those air freight attributes important for the firm to select air freight services?

1d. How are the air freight service attributes which are important for the firm covered in the delivered service today? I.e. is there a gap between the demanded service level and the perceived service level? On a scale from 1 to 7 (1 = outstanding, 4 = average, 7 = poor) how would you rank the level of received services?

- o Costs: 1 2 3 4 5 6 7
- o Delivery time: 1 2 3 4 5 6 7
- o Frequency: 1 2 3 4 5 6 7
- o Security: 1 2 3 4 5 6 7
- o Quality: 1 2 3 4 5 6 7

Follow up question: What is the reason of a particular high or low importance ranking?

1e. Are there any bottlenecks experienced by the firm regarding the use air freight services?

Follow up question: How are the bottlenecks caused and how 'disruptive' are they for the firms supply chain?

Type of products

2. What type of commodity is the firm transporting with air freight and how would you describe its characteristics?

- *Commodity:* e.g. food, high-tech products, consumer products, electronics, chemicals, machinery etc.
- *Characteristics:* e.g. value, weight, perishable, fragile, size etc.

3a. What is the function of the transported product by air freight services for the consignee?

- E.g. spare part, service part, input to production etc.?

3b. When the product is defined as a service product or spare part, is the product accompanied by service personal from the firm, and does this cause any issues regarding routing, frequency etc.?

4a. What are the desired minimum and maximum transportation lead-times for the products which are transported via air freight services?

Follow up question: Are those lead-times always realized or not? If not, why not?

4b. How would disruptions (i.e. delays) in the air freight supply chain influence:

- Production lead-times for your firm?
- The production process of your end customer?

5a. When designing new products, is it considered that the product has to be transported by air freight (e.g. the use of modularisation)?

5b. If yes, what are the consequences for the product? (E.g. more expensive, less functional, less value for customer, investment in capita etc.).

6. In what state of the product life cycle are products which are transported by air freight?

- Introduction
- Growth
- Maturity
- Decline

7. What is the importance of the products which are transported via air freight services for both the firm and the customer?

** Importance defined according to the ranking of an 'ABC-analysis' methodology:*

A – 20% of the product assortment accounts for 80% of the firm's turnover

B – 30% of the product assortment accounts for 15% of the firm's turnover

C – 50% of the product assortment accounts for 5% of the firm's turnover

Importance for firm:	Importance for customer:
o High importance *(A)*	High importance *(A)*
o Medium importance *(B)*	Medium importance *(B)*
o Low importance *(C)*	Low importance *(C)*

** Importance defined according to the Kraljic Matrix:*

Importance for firm:	Importance for customer:
o Leverage products	Leverage products
o Strategic products	Strategic products
o Non-critical products	Non-critical products
o Bottleneck products	Bottleneck products

8a. How would you describe the intensity level of the use of air freight following the following scale (week = Monday-Sunday)?

Single items shipped:	Consolidated items shipped:
o < 5 items per week	< 5 orders per week
o Between 5 and 10 items per week	Between 5 and 10 orders per week
o > 10 items per week	> 10 orders per week

8b. If consolidated orders are shipped, how many items does a consolidated order normally contains on average?

Supply chain management

9. Who is the decision maker (focal player) if airfreight is used as mode of transportation, the firm or the end customer, and why?

10a. Is the transportation of RAW-materials and end products managed in-house or outsourced to a logistics service provider?

- Managed in-house because:
- Outsourced to LSP because:

10b. If logistics is outsourced, what where the main incentives to select your current air logistics service provider (freight forwarder)?

- Service level
- Quality
- Costs
- One stop shopping
- Other_____

11. If air freight services are used both in the backward and forward supply chain, how would you indicate the share of imported versus exported products by air freight measured in volume and value of the products?

Volume:

- Import:_____%
- Export:_____%

Value

- Import:_____%
- Export:_____%

12. How would you indicate the level of vertical integration in the firms supply chain? (e.g. completely vertical integrated, only backward integrated, only forward integrated).

Materials management

13a. What type of production systems is the firm using (e.g. make to order, make to stock etc.)?

13b. Does the type of production system influence the demand for air freight services?

14. Does the use of air freight services impacts the amount of inventory (costs) in the total supply chain solution (i.e. is air freight substituting the function of inventory in the firms supply chain)?

Follow up question: If yes, how does air freight services impacts the amount of inventory in the firms supply chain and impacts the flexibility of the firm?

Internationalization

15. How can the size of the firm be best describes, according the below mentioned scale?

- Small (< 50 employees)
- Medium (between 50 and 250 employees)
- Large (> 250 employees)

Follow up statement: map both the size of the entire company and the size of the business unit where the respondent is located.

16a. Where is the gross of your end customers (major market) located, which are buying your principal product or service?

16b. In terms of internationalization, how would you describe the geographical distance between your firm and your end customers?

- Local (short distances)
- Regional
- National
- International (long distances)

17a. Where are the most important suppliers located which providing the firm with raw-materials/ production parts?

17b. In terms of internationalization, how would you describe the geographical distance between your firm and your most important suppliers? (i.e. local or global sourcing)

- Local (short distances)
- Regional
- National
- International (long distances)

18a. What is the main airport of origin which the firm is using?

18b. What is/are the main airport(s) of destination where the firm is shipping to?

19. Has the availability of air freight services enables the firm to expand their business practices on a global scale?

- Yes. Explanation:
- No. Explanation:

20. Did the availability of air freight services in the Møre og Romsdal region influenced your decision to locate or move your firm in Møre og Romsdal?

Conclusion Statements

21. What are the main pros and cons of using air freight services as seen from the respondent's point of view?

22. What would be the most important improvement for the respondent in the air freight supply chain in terms of level of service and quality?

INTERVIEW SCHEDULE

	Interview date	*Method*	*Duration*
Firm A	09.03.2012	Face-to-face	45 min.
Firm B	12.03.2012	Face-to-face	60 min.
Firm C	14.03.2012	Via e-mail	n.a.
Firm D	16.03.2012	Face-to-face	45 min.
Firm E	30.04.2012	Face-to-face	90 min.

Table E-3: Interview schedule multiple case study.

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